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Director's Biennial Report—1926-1928

September, 1928

Agricultural Experiment Station
Oregon State Agricultural College
CORVALLIS

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TO THE PRESIDENT OF THE COLLEGE

Sir:

I have the honor to submit herewith the report of the Agricultural Experiment Station of Oregon State Agricultural College for the biennium ended June 30, 1928. It includes a brief account of the work and results during the two years, and again directs attention to certain urgent needs of the Station.

J. T. JARDINE,
Director.

September, 1928.

Director's Biennial Report

OREGON AGRICULTURAL EXPERIMENT STATION

1926-1928

September, 1928

THIS report continues the record of Station work presented in the past four biennial reports. Activities of the Agricultural Experiment Station for the two years ended June 30, 1928, are discussed briefly and important needs of the Station in the way of land and improvements are pointed out.

Form and scope of the report are similar to preceding reports in order to make the record continuous for reference. Results of the investigations are printed in bulletins, circulars, circulars of information, and press articles, as rapidly as they are available for the information of farmers, the general public, and other investigators. The Director's Biennial Report is not designed or intended for such use.

The Station program of investigations was again expanded somewhat during the biennium as a result of increases in the Federal Purnell funds, slight increases in state funds, and additional cooperation from the United States Department of Agriculture. On the other hand, the demand for investigations and assistance from the Station increased more rapidly than the program of investigations, leaving a greater number of requests than heretofore without attention at the beginning of the new biennium, July 1, 1928.

EXPANSION OF STATE AND FEDERAL SUPPORT FOR RESEARCH

AT ITS session in January, 1927, the State Legislature reenacted existing state appropriations and, in addition, provided an increase from $10,000 to $15,000 per annum for dairy investigations, including dairy diseases; an increase from $5,000 to $7,500 per annum for poultry disease investigations; an increase from $7,500 to $10,000 per annum for investigations in soils, irrigation, and drainage; a special item of $8,000 for establishing irrigation by deep well pumping on eighty acres of land at Burns; and a continuing annual appropriation of $2,000 for crop rotation and nursery experiments in Eastern Oregon, especially in Umatilla county.

The Federal Purnell Act, passed by Congress and approved by the President February 24, 1925, has increased by $10,000 each fiscal year. This increase along with the state increases has been effective even in excess of the amount of the increase. The additional funds have made possible more thorough attack on important problems and have made

possible organization of cooperation to obtain effective assistance of Federal agencies working along lines of special importance in Oregon.

COOPERATION WITH THE UNITED STATES DEPARTMENT OF AGRICULTURE

WITH additional funds available, special effort was made to organize State and Federal resources in the most effective joint research on problems of the state. Most of the cooperation established previously was continued and in some cases expanded. A considerable amount of effective new cooperation was obtained.

Cooperation continued. Forage crop investigations were continued in cooperation with the Office of Forage Crop Investigations, Bureau of Plant Industry. Of this same Bureau, the Office of Cotton, Truck, and Forage Crop Disease Investigations increased cooperation and assigned a man to Corvallis for potato disease investigations; the Office of Pine Blister Rust Control continued the campaign to control white pine blister rust; the Seed Laboratory continued its office at Corvallis; the Moro Branch Station was continued in cooperation with the Office of Cereal Investigations; and the Branch Station at Hermiston in cooperation with the Office of Western Irrigation Agriculture Investigations.

The soil survey in cooperation with the Bureau of Soils was continued and representatives of this Bureau assisted in economic surveys of irrigation projects.

The Bureau of Agricultural Economics gave valuable assistance in a study of the raw milk situation around Portland.

The Division of Agricultural Engineering, Bureau of Public Roads, continued cooperation in studies on methods of irrigation and assisted in making economic surveys of irrigation projects.

New cooperation. The Division of Agricultural Engineering, Bureau of Public Roads, materially increased its cooperation. Without the assistance of this division it would have been difficult for the Oregon Station to meet the request of the State Securities Commission for economic and feasibility surveys of such reclamation districts as the Ochoco, Warm Springs, Grants Pass, and Tumalo. The state profited greatly by this assistance from the Federal department. The cooperation with this Bureau in studies on methods of irrigation and water utilization was expanded before the close of the biennium. An outstanding agricultural engineer was employed cooperatively to spend full time on such investigations.

The Office of Cotton, Truck, and Forage Crop Disease Investigations increased cooperation by assigning additional assistance to Corvallis to work on bulb diseases beginning with the fiscal year 1927-28. Before the close of the biennium this office had agreed upon still further cooperation in connection with "curly-top" disease of truck crops.

Cooperation was started in 1927 with the Office of Drug, Poisonous, and Oil Plants, of the Bureau of Plant Industry, in a study of rose production for perfume.

Beginning January 1, 1928, cooperation with the Bureau of Plant Industry was started on investigation of perennial apple canker and related diseases. This cooperation was most timely as the perennial canker was rapidly becoming a limiting factor in production.

Existing informal cooperation with Plant Industry on strawberry investigations was materially expanded late in the biennium.

An investigation on the standardization of butter, in cooperation with the Dairy Bureau, was started in June, 1928.

Funds were obtained for the Office of Dry Land Agriculture to cooperate with the Oregon Station in establishing and maintaining a branch experiment station near Pendleton, Oregon, beginning July 1, 1928.

Cooperation was arranged with the United States Geological Survey for a joint investigation of ground water in the Willamette Valley, beginning July 1, 1928.

Arrangement was made with the Bureau of Entomology for cooperation in the study of "curly-top" disease, centering especially at Hermiston, Oregon.

In addition to the foregoing formal cooperation, representatives of the United States Department of Agriculture rendered valuable assistance at different times throughout the biennium in the diagnosis of agricultural problems. The cooperative joint attack in all of the technical phases was on a larger scale than in any previous period.

COOPERATION WITH THE OREGON STATE COMMITTEE ON RELATION OF ELECTRICITY TO AGRICULTURE

The Oregon State Committee on Relation of Electricity to Agriculture was organized in May, 1924. The organization and purpose of the committee were reported briefly in the report of the last biennium.

The Director of the Agricultural Experiment Station continued as Chairman of this committee during the biennium just closed, and the Station was responsible for the program of investigations sponsored by the committee. The committee financed this program to the extent of $6,000 each year; and, in addition, equipment companies were liberal in cooperating by the loan of field and laboratory equipment.

The cooperation of utilities and equipment companies and farmers in these investigations has been most encouraging.

COOPERATION WITH STATE AGENCIES

THE policy of the Agricultural Experiment Station is to render cooperation to other state agencies whenever feasible and within the province of the Station as the state agency responsible for research having to do with agriculture in all its phases. The following represent major illustrations of such cooperation during the biennium.

Just before the close of the preceding biennium the Station undertook cooperation with the State Irrigation Securities Commission, in an economic and feasibility survey of the Ochoco district. The Station staff was responsible for seeking and obtaining cooperation of the Division of Agricultural Engineering, Bureau of Public Roads, in this survey. This cooperation was continued throughout the biennium just closed. Thorough studies were made of the Ochoco, Warm Springs, Grants Pass, and Tumalo projects. These reports furnish the information for reorganization and refinancing of the irrigation districts reported upon. The rather complete, thorough statement of facts has been made possible by the assistance of the Federal Bureau of Public Roads, and the cooperation of the State Engineer's Office.

The biennium will long be remembered by Agricultural Experiment Station workers and fruit growers. Before the end of July, 1926, trouble arose in reducing the spray residue on fruit to a point within Federal requirements for interstate shipment. The Station had already begun investigations to develop new methods for cleaning the fruit, and throughout the biennium has concentrated the skill and effort of several departments of the Station on this problem. As a result, the hydrochloric acid wash has been developed until it is working with fair satisfaction. The Station, of course, had no regulatory authority for shipping-point inspection of such fruit. The State Dairy and Food Commissioner has this responsibility and authority for the State of Oregon. Beginning in 1926, there has been most hearty cooperation between the Dairy and Food Commission and members of the Experiment Station staff. The Station has furnished technical assistance and advice and at times the staff members have acted as deputies of the Dairy and Food Commissioner. The cooperation is an example of effective joint service to the people of the state in time of emergency.

The Station department of Bacteriology has cooperated with the Dairy and Food Commissioner also in a study of the market milk supply of towns in Oregon, including a complete test of the milk and a survey of conditions under which the milk is produced.

As in past years, also, Station staff members have cooperated with the State Horticultural and Plant Quarantine Board, and with the State Livestock Sanitary Board, furnishing technical advice and assistance, especially in connection with insect and plant and animal disease problems. The cooperation has been harmonious and effective, considering the great number of problems and the small organization of the Station to handle them.

Late in the biennium cooperation was started with the Oregon State Fish and Game Commission. At the request of the Commission the Agricultural Experiment Station will assist in a cooperative study of the economic status of the China pheasant in Oregon. The study will be financed largely by the Fish and Game Commission. The Station will examine several hundred specimens of birds submitted by the Commission.

SOME OUTSTANDING STATION ACCOMPLISHMENTS OF THE BIENNIUM

IN EACH biennial report a few illustrations are given of investigations which have reached the point to indicate results of outstanding importance during the biennium. The following are illustrations of such accomplishments during the two years ending June 30, 1928.

Removal of spray residue. The most outstanding accomplishment of the biennium has been the development of what appears to be a fairly satisfactory practical solution for meeting the requirements of the trade as to the removal of spray residue from fruit. The problem in this connection came as an emergency during the winter of 1925-26, when fruit was denied release for sale in Eastern markets and shippers were compelled to unpack and further clean the fruit at great expense in terminal markets. About the same time Great Britain indicated that American fruits, especially apples, must not carry in excess of .01 grain of arsenious oxide per pound of fruit.

Early in 1926 the Oregon Agricultural Experiment Station staff began a study of the situation with a view to finding a solution for the spray residue problem. It was soon decided that there could be no hope of an effective change in spraying practice soon enough to meet the situation in a practical way. Attention was promptly given to possible means of removing the residue from the fruit without impairing the quality of the fruit. This led to preliminary laboratory tests of some fifty or more chemicals in a hurried search for an effective solvent of spray residues non-corrosive on fruit tissues through short periods of contact. When the real emergency came during the harvest of 1926 the preliminary laboratory tests had already indicated that water solutions of hydrochloric acid would be the safest and most generally serviceable.

In that short time, however, only laboratory tests had been possible. Storage tests comparable to commercial conditions following the use of such acid solutions were lacking. The Station staff, therefore, could go no further than to suggest the acid solution. Acting upon this suggestion, a considerable amount of Oregon fruit was treated in a water solution of hydrochloric acid to remove the residue. The results were fairly satisfactory.

The Station, the growers, and the equipment manufacturers continued their efforts following the close of the season, and by the harvest season of 1927 there were a number of practical commercial machines on the market. The Station continued with harvesting, storage, and cleaning *tests running into thousands* and including all known phases of the problem and prospective ways of meeting them.

The outcome is that the Oregon fruit industry is facing the harvesting and marketing of a large fruit crop in 1928 with real confidence that the pack will be one of the best, if not the best, ever harvested as regards quality, freeness from residue, and general appearance. There is confidence that international and national requirements will be met, and by methods which are economically feasible.

This may be looked upon as a test of the Agricultural Experiment Station such as may come only once in a half century or longer. It was

a real emergency and has been met. The greatest of credit is due the Station staff for unselfish effort, long hours, and intelligent follow-up of the experimental work to its ultimate satisfactory application in practice. Likewise, the highest commendation is due the fruit growers of the state and the equipment manufacturers of the Pacific Coast. The co-operation of these three agencies is jointly to be credited with meeting a situation which gave every promise of wrecking one of our most important industries.

The value of Station findings in this connection has been estimated in millions of dollars. A better measure is the actual fact that the greater part of the fruit crop was practically embargoed until a solution of the problem was found.

Control of strawberry Root-Weevil. For many years the strawberry Root-Weevil has been a menace to the strawberry industry in Oregon, and in late years has been the most important limiting factor. Shipments from one community dropped from 100 cars to 30 cars in about three years. During the biennium the poisoned bait method of combating strawberry weevils has been adapted to Oregon conditions with such effectiveness that growers no longer look upon this pest as a limiting factor or a serious hazard.

The poisoned bait method of control was not first worked out in Oregon, but as applied elsewhere would not have solved the Oregon problem. Application in Oregon must be made during harvest rather than after harvest; it has been found necessary to apply bait early in the spring for over-wintering weevils; it has been found that there is not one but several species of weevil to be controlled, each requiring special study and treatment. The Federal Purnell fund has made it possible to continue the investigation vigorously in the laboratory and in the most important growing sections, and a practical solution has been adapted to field conditions. The fact that an important industry has been saved is the best measure of the economic importance of the Station results.

"Curly-top" of vegetables diagnosed. The findings or the discoveries by research in the department of Botany and Plant Pathology in connection with this problem are somewhat different in character but of no less ultimate economic importance than even the findings in connection with spray residue. For example, tomatoes have been seriously affected for thirty years with a disease known as "Western Yellow Tomato Blight" and no appreciable progress had ever been made toward a solution or a diagnosis of the problem. In 1926 this Station discovered this was due to the "curly-top" virus. Squashes, horseradish, peppers, beans, and other crops were also found to be seriously affected.

The "curly-top" virus was recognized as the causal disease in many of our important truck crops. This explained a condition that had been most puzzling in the Western States. The way is now open for progress in control of the malady.

Tulip mosaic. The breaking of tulips is a condition that has been known for fully three hundred years and generally considered to be a sport or variation. During recent years the view that it is a disease has

been gaining ground. Work at the Station during the biennium proved conclusively that it is an infectious mosaic disease readily transmitted by aphids and by inoculations. Means are readily available now for controlling it by roguing, isolation, etc. Interest is attached to this progress because this is now considered to be the oldest plant virus disease on which we have any authentic information in literature.

Control measures for infectious abortion in dairy cattle. Reliable facts indicate that this disease has for years been costing dairymen of the state between $1,000,000 and $2,000,000. This is occasioned through loss of calves, attendant sterility, decrease in milk flow, and secondary diseases. Many dairymen have been forced out of business.

Investigations of the disease from many angles has been the major research work of the Veterinary Medicine department and the Dairy department in cooperation during the past eight years. As early as three years ago what was believed, from experimental results, to be a practical possibility of eliminating the diseased animals and building up healthy herds under field conditions had been worked out. During the past biennium special attention has been given to practical tests of this method in cooperation with leading dairymen. Such experiments are under way in fifteen counties with good results in nearly every herd. As a result of this procedure a number of leading dairymen now have clean herds.

The results have been so satisfactory that in recent months recommendations for practical application of the Experiment Station recommendations in dairy management throughout the state have been made to the State Livestock Sanitary Board. These recommendations have been accepted by the State Livestock Sanitary Board and, based upon them, the Board has evolved a plan for accrediting dairy herds and areas where dairying is carried on. In two localities movements are already started to eradicate the disease in cooperation with the Livestock Sanitary Board and the Extension Service.

Since this disease is more destructive to dairy herds in Oregon than is tuberculosis, there is justification for considering this accomplishment of the Station as a real outstanding development.

Immunization against coccidiosis in poultry. Experiments have proved: (1) small doses of coccidia do not necessarily produce symptoms in susceptible birds; (2) repeated small doses produce a very high resistance; (3) such resistance can be regularly produced through the regular administration of sublethal doses of coccidia.

It has been shown that there is a strain of coccidia which attacks the caeca only and another strain which attacks the small intestine only. Immunity against one strain does not necessarily protect against the other.

These findings are of outstanding importance because of their promise in control of coccidiosis in poultry, which has been one of the most troublesome of poultry diseases. The findings establish or lay the foundation for control through proper sanitation. Field tests on a practical scale already are supporting the experimental conclusions.

Improved method of vaccinating young fowls against chicken-pox. An improved method of vaccinating young fowls against chicken-pox has been worked out. Vaccination is in the skin, and not subcutaneous. Unattenuated virus is used. Immunity is produced in four weeks or less. This immunity has lasted at least two years in some fowls. About 60,000 birds have been vaccinated by this method.

This method is of outstanding importance because of great reduction in cost of vaccination, vaccination at a time more advantageous to production, the establishment of immunity for a longer period, and much less liability of loss following vaccination.

Facts bearing on taxation. During the biennium a study in the ratios of assessed values to sales values of real property in Oregon was completed and the data published as Station Bulletin 233. These facts have been favorably received by tax experts as of special value.

The Oregon Voter of July 21, 1928, classes the bulletin presenting the facts of this study as "the most important contribution in recent years toward accurate knowledge of what is behind the tax complaint, which seems to be so much louder in Oregon than in most States."

A promising new legume. Austrian winter field peas introduced and selected in connection with forage crop investigations have promise of real value in Western Oregon. They are well suited to many of the medium heavy soils in the Willamette Valley. There is much demand for the seed in the Southeastern States, where winter hardiness is necessary.

There are a few limitations to the crop, including susceptibility to aphid injury and attack by pea weevil. As a whole, however, this pea seems to be the outstanding new legume in recent years.

ADDITIONAL INVESTIGATIONS REQUESTED FOR BIENNIUM

ALTHOUGH the Station program of research was materially expanded during the biennium through additional State and Federal funds, and by additional cooperation from Federal Bureaus, there are at this writing perhaps more urgent requests for investigation of other problems than at any time in the history of the Station. The following indicate the character of such requests:

Plant disease and insect-pest problems

(1) Investigations to work out control of prune thrips.

(2) Investigations to work out control of syneta leaf-beetle.

(3) Investigations to develop control of strawberry crown-borer. This has been undertaken in a limited way with Federal funds.

(4) Investigations for control of codling-moth in walnuts.

(5) Investigations to develop substitutes for lead arsenate sprays.

(6) Investigations for control of pea weevil on Austrian winter field peas. This crop has great promise for the Willamette Valley, but damage by the pea weevil is a limiting factor.

(7) Investigations of leaf nematodes, root knot nematodes, and other nematodes. Quarantine measures have been necessary this year to control the spread of clover and strawberry nematodes. The nematode is causing losses and concern in alfalfa.

(8) Investigations for control of walnut blight, which is increasing in Oregon.

(9) Investigations of perennial canker of apples. This has been taken care of largely as a result of appeals from the Station to the United States Department of Agriculture.

(10) Investigations into the nature and control of an apparent mosaic disease of rose stocks.

(11) Investigations to establish freedom of Oregon Strawberry plants from a disease known as "strawberry yellows." California markets for Oregon plants, to the extent of about $45,000 are involved in ability to certify freedom from this disease.

(12) Investigations of mosaic in greenhouse tomatoes, an increasingly troublesome disease.

(13) Investigations of foot rot in wheat. Some 1,200 acres of winter wheat were seriously injured by this disease in Wasco county this year.

(14) Calls for investigation and assistance in connection with wilt of horseradish, cucumber mildew in greenhouses, root rot of beans, tomato blight, diseases of ornamental shrubbery, diseases of hyacinths, asters, peonies, bulbous iris, and cherry bud blight.

With such problems as the complicated spray residue difficulties, codling-moth control, perennial canker, pear blight, red spider on pears, strawberry weevil, many species of aphids, diseases of potatoes, diseases of bulbs, the destructive curly-top of vegetables, etc., already before the Station, in addition to thousands of calls for assistance, investigation of the problems listed above can not be looked for within the next two years without an increase in funds.

Animal disease problems

(1) Disease known as "stiffness in lambs." Losses estimated at $150,000 per annum.

(2) A disease of ewes carrying lambs. Losses estimated at $120,000 per annum.

(3) Chronic pneumonia in sheep. Losses estimated at $50,000 per annum.

(4) Investigations of an apparently new disease or poisoning among cattle in the Columbia Basin. About 175 head died in the vicinity of Grass Valley, Oregon, this year. In spite of all efforts, no remedy has been found.

(5) Diseases of turkeys and management problems of turkeys. Practically nothing has been done for the turkey-growing industry in the state.

(6) Range paralysis in poultry. Losses slight but increasing.

(7) Infectious dysentery of cattle. Losses estimated at $25,000 per annum.

Other problems

(1) Control of weeds. Oregon agriculture, like agriculture in other states, is confronted with a growing problem of weed control. Canada thistle, Russian Knap weed, and Hoary Cress are a constant menace. Limited experiments looking toward eradication have been undertaken, but little progress has been made, due to lack of funds.

(2) More thorough investigations to devise ways of improving pastures. Lack of suitable pasture is the limiting factor in dairying and livestock production on farms in Oregon.

(3) Use of combines as harvesters of small seeds.

(4) Potato storage investigations.

(5) The study of poultry feeds. The importance of this problem is evidenced by the effort of the poultrymen to obtain special appropriations for such work in 1926.

(6) Investigations into causes and control of dark colored egg yolk.

(7) Duty-of-water studies in connection with adjudication of water rights in the John Day Valley.

(8) A survey of drainage and flood problems in the Coquille Valley.

(9) Drainage and irrigation problems in the Rogue River Valley.

(10) Costs and efficiency in honey production.

(11) Railroad rate information.

A small part of the problems listed will perhaps be undertaken within the next biennium if present appropriations are continued without reduction.

SERVICE

THE primary function of the Agricultural Experiment Station is the accumulation of facts through research and experimentation for solution of problems confronting agriculture and rural life. The facts are brought together in bulletins, circulars, circulars of information, and in journals and reports available to the Extension Service. The fact-finding responsibility, strictly speaking, might be considered closed when the above task is well done.

In addition, however, the Station staff, as a group, constitutes a clinic and an information bureau. The service called for and rendered through personal interviews, letters in reply to requests for information, identification of insects, plant and animal diseases, soils, fertilizers, milk and water specimens, and addresses and radio talks undoubtedly is of great value to the state. This service, in the main, is rendered in cooperation with the Extension Service and resident teaching and is jointly financed.

At times the calls upon Station specialists seriously tax the Station organization and endanger progress in the real task—fact finding. Following is a careful estimate of such activities for one year.

Estimated service for one year, July 1, 1927 to June 30, 1928

1.	Letters in reply to requests for information	26,300
2.	Consultations with individuals seeking information	11,800
3.	Identification of plant specimens	460
4.	Identification of insect specimens	2,100
5.	Tests for bacillary diarrhea in poultry	193,000
6.	Tests for infectious abortion in dairy cattle	15,000
7.	Germination and purity tests of seeds	1,630
8.	Purity tests of milk	1,200
9.	Purity tests of water	1,000
10.	Soil analysis and identification	300
11.	Distribution of vaccine (doses)	10,000
12.	Legume culture for (acres)	7,000
13.	Address at public meetings	500
14.	Radio talks more than	100
15.	Exhibits at State, Pacific International, and County Fairs.	
16.	Popular articles and press notices—several hundred.	

Not infrequently letters require the consultation of several specialists, others call for library study, and many require critical examinations and laboratory work on specimens.

As agriculture becomes more of a business and more complex, the calls for such service increase.

Station field days. Station field days were held at the Astoria, Moro, Union, and Burns branch experiment stations, and at field nurseries in six or more counties where Station nurseries are maintained. The attendance fairly well represented the territory served by these stations. At the Astoria Station, for example, about 150 cars brought people from Tillamook county. On another day, farmers from Columbia county visited the Station; on still another day nearly 600 persons of Clatsop county visited the Station. The Moro Station had separate field days for counties in that district, and in addition, had field days at the nurseries.

The contact of farmers with work through this medium of field days is increasing.

Exhibits. The Station made a rather elaborate exhibit at the State Fair each year. Attempt was made to bring to the public Station accomplishments which have reached development to warrant changes in field practice. Branch stations, as well as the Main Station at Corvallis, were represented in the exhibits.

In part, the State Fair Exhibit was displayed also at the Pacific International Livestock show.

Regulatory. The Station staff administered the State Fertilizer Inspection Law, the Lime Law, the Insecticide and Fungicide Law, the

Dairy Bull Registration Law, and the Stallion Registration Law. Valuable service is rendered in this connection at comparatively small expense, by using the background of Station facts and trained staff members when they are needed, without duplicating overhead expense.

LAND NEED IMPERATIVE

THE need for land has been stressed as urgent in past reports. The situation at the close of this biennium is more acute than heretofore. The expansion of the campus westward has taken over crop rotation experiments which have been under way for some twenty years.

Only about 100 acres of land owned by the College is available for Agricultural Experiment Station work in farm crops, horticulture, soils, and irrigation. Such acreage is meager compared with a farm of more than 500 acres at Washington State College; 1,400 acres at Kansas State College; approximately 2,000 acres at Indiana; more than 600 acres at Idaho; nearly 600 acres at Colorado. Meantime, problems in the field of farm crops, soils, and horticulture are increasing, owing to changes in agricultural practices, and the development of new crops such as flax, vetches, pasture, and seed crops.

The situation as regards land for both experimental and teaching needs has been carefully studied the past few months. Under date of April 25 a special report on the subject was submitted jointly by the Dean of Agriculture and the Director of the Agricultural Experiment Station. The following was recommended as a land program which should be adopted at the earliest possible moment:

Kind of land (soil type)	Farm Crops	Horticulture	Soils	Total
	acres	*acres*	*acres*	*acres*
Brown valley floor soil (Willamette silty clay loam)	340	——	80	420
Upland	80	168	40	288
River-bottom	80	65	20	165
Total	500	233	140	873

The joint recommendation of the Dean and the Director is for purchase first of 420 acres of brown valley floor soil for farm crops and soils. This is needed for experimental plantings in the fall of 1928. If not obtained by purchase, such land must be rented, or important experimental work must be curtailed. No suitable land has been found available for rent.

As second purchase, the 288 acres of hill land was recommended in order to meet the needs of horticulture and certain needs for experiments in farm crops and soils.

The purchase of approximately 165 acres of river-bottom land was recommended as a third item of purchase, not because experimental work of this type is less important but the Station now has under rental approximately 150 acres of this land which can be held for a few years.

Each of these land types represents a large area of agriculture in Western Oregon—agriculture which depends more and more upon the

Station and the College for facts as to crops and methods basic to success. Rented land is not only unsatisfactory for experimental work but is uneconomical. Continuous record, which is of primary importance, is not possible on rented land, nor is it possible to adopt cropping system and management which should be a part of the experimental work over a period of years. This means operating under conditions such that efficiency is impossible. The need for land can not be emphasized too strongly if the Station is to function as it should in meeting its growing responsibilities.

STORAGE FACILITIES

THE need for storage facilities for the care of valuable seed stocks and for experimental work has been called to attention in previous reports. Such space is needed for service by all departments.

There is now no suitable common storage for use in properly caring for seed stocks and materials which must be carried over from year to year.

Many thousands of dollars are being expended, for example, in studies of potato diseases, bulb diseases, and diseases of other crops. These studies necessitate the carrying of planting stocks and experimental materials, especially bulbs and potatoes, in large numbers under conditions which will satisfy experimental control. It is a problem each year to find a way to take care of these materials without jeopardizing the entire experimental work.

The need is perhaps even greater with experimental work in farm crops. Many varieties of seeds must be carried over clean, and stored under conditions satisfactory to experimental procedure. This department is forced now to handle its seed under conditions that a practical seed grower would not consider. The situation is such as to endanger seed stocks of great value, promote loss of seed, and impair prestige of the Station work with both dealers and growers.

There is real need for storage shed facilities for equipment, including automobiles. Machinery and cars are now stored in every nook and corner which may offer temporary shelter. There is no opportunity to encourage systematic, business-like management and procedure. The changes in conditions and the expansion in the Station program have resulted in the condition of totally inadequate storage space in all lines. Plans should be considered for providing institutional storage space.

ADDITIONAL OFFICE AND LABORATORY SPACE NEEDED

Construction of the new Poultry-Veterinary Building during the biennium has been of material assistance in relieving crowded conditions for laboratory and office space in the Veterinary Medicine department. The Station work of this department had grown to include from five to seven full-time workers, besides three project leaders on part-time. This whole staff was housed in approximately the same space that the department had when there was very little Agricultural Experiment Station

work. This relief was timely, as the increasing requests for assistance in the control of animal diseases indicate the necessity for still further expansion in the Veterinary Medicine research.

Botany and Plant Pathology needs more space. The increasing number and serious nature of plant disease problems have led to maximum effort in obtaining cooperation from Federal bureaus and offices. As indicated under Federal cooperation, the Bureau of Plant Industry is now financing a large part of our cooperative investigations on diseases of bulbs, diseases of potatoes, and "curly-top" disease of vegetables. In addition, the department has one man assigned here working on insecticides and fungicides, and a man assigned here in charge of white pine blister rust control. As a result of this cooperation, primarily, Botany and Plant Pathology has had more than 100 percent increase in staff without any increase in office space. Conditions are now too crowded for satisfactory and efficient work. One laboratory formerly used by two men is now used by four men. A temporary arrangement is being worked out for the present year. The list of requests for additional investigations indicates that work in this field will have to be expanded, either at the Oregon Station or by some other agency. The probable expansion and need for additional space, therefore, must be kept in mind.

Entomology needs more space and an insectary. Entomology, like Botany and Plant Pathology, has an increasing number of problems. Attempt has been made the last few years to expand the staff in this department by using advanced and graduate students. As in the case of Pathology, also, effort has been made to arrange cooperation with the Federal Bureau.

At present the Station workers have office desks in the Station laboratories. Graduate research workers and Government entomologists have desks in these same laboratories. Eight men are now occupying two Station rooms, and during the college year certain advanced classes in Economic Entomology meet in these same Station laboratory rooms. Visitors, conferences with growers and members of the college staff, the mixing of sprays, emulsions, and other disturbing activities all take place in these same two rooms.

Obviously, the situation is not conducive to most effective work. As far as practicable, research men should have desks somewhere away from confusion and disturbance.

Entomology is much in need of an insectary. A building screened on four sides, with a shingled roof, is needed for rearing and studying insects under outdoor conditions. This probably would not cost in excess of $300.

Entomology, as also Pathology, is in need of land. The land recommended for purchase for the Agricultural Experiment Station, however, covers the requirements of these two departments.

Space for Director's Office needed. The Director's Office consists of two very small rooms. The program of investigations through increased funds and greatly increased Federal cooperation is about three times what it was in 1920. With eight branch stations and many contacts in the field, and with the increased number of reports and require-

ments in the administration of both State and Federal work, efficiency in the research work necessitates additional help in the Director's Office. A man qualified in agriculture, but having ability to assist with preparation of publications, reports, publicity, and meeting the public, is needed for most effective handling of the Station work.

Request for such help has been delayed because of lack of office space. Brief consideration of the program of investigations, the wide contacts of the Station, the amount of publications, and the Director's present limited office space should make clear the need for additional space and the additional assistance.

GREENHOUSES

IN PRECEDING biennial reports greenhouse space has been set forth as a most urgent need. The completion of the new greenhouses during the biennium has made available 6,600 square feet of greenhouse space in two units exclusively for Station work. In addition, certain Station investigations are conducted in two other similar units assigned primarily to resident teaching. These greenhouses are strictly modern, and meet satisfactorily a most urgent need. They are already effectively in use.

EQUIPMENT

URGENT need for investigations, always much greater than available funds can meet, has made necessary a policy of purchasing equipment only to accommodate the specific needs of investigation. The Station could profit greatly by greater expenditure for equipment.

PUBLICATIONS

TWELVE Station bulletins, nine Station circulars, and eleven circulars of information were prepared and issued during the two years. As in former years, the editions were small, ordinarily from three thousand to five thousand copies. This is a smaller number of publications than the preceding biennium, due in part to the development of the new Station series, "Circulars of Information," and in part to the publication of technical results in outside journals.

The circular of information is a mimeographed circular intended to present results of progress together with recommendations, perhaps, for a single season and in advance of developments which warrant publication in circular or bulletin form. This series meets an important need, and makes it possible to defer printing publications longer than otherwise.

More than 100 articles technical in character were printed in national and regional scientific journals and farm journals. This policy makes results of research available to research workers and reserves the limited Station funds for Station publications of interest primarily to the general public.

As in past years, no individual mailing list for publications of the Station has been maintained. Individual copies are furnished on request. Requests for copies in numbers are filled only on approval by the Director. With cooperation of interested persons this policy will result in each copy of Station publications reaching some one who is particularly interested in the subjects reported. Editions can in this way be kept to a minimum in size, thereby allowing the printing of more numbers in each series than would otherwise be practicable with limited funds.

There are occasional complaints because individual mailing lists are not maintained, and because new publications are exhausted within a few months. Effort is made, however, to have copies on file in libraries which have any considerable patronage interested in subjects such as are reported in station publications. The following publications were issued during the biennium.

Bulletins

No.	Title	Edition	Pages
224	Wintering Stock Steers	5,000	15
225	The Cranberry in Oregon	5,000	31
226	A Progress Report on the Removal of Spray Residue from Apples and Pears	10,000	46
227	Walnut Drying and Packing in Oregon	5,000	28
228	Investigations on the Harvesting and Handling of Bosc Pears from the Rogue River Valley	5,000	30
229	Cattle Marketing Investigations at Portland, Oregon	5,000	15
230	Immunity or Resistance of the Chicken to Coccidial Infection	5,000	32
231	Electric Lights for Increasing Egg Production	5,000	40
232	The Eradication of Infectious Abortion from the Dairy Herd of Oregon State Agricultural College	8,000	12
233	A Study in the Ratios of Assessed Values to Sale Values of Real Property in Oregon	5,000	45
234	The Removal of Spray Residue from Apples and Pears	5,000	38
235	Economic Limit of Pumping for Irrigation (in press)	4,000	48
236	Field Crops for Pump Irrigation at the Harney Branch Experiment Station (in press)	3,000	32

Circulars

No.	Title	Edition	Pages
77	The Hessian Fly in Oregon	2,500	7
78	Commercial Fertilizers, 1927 Edition	2,500	22
79	The Strawberry Root-Weevils and Their Control in Oregon	4,000	24

80	Japanese Barnyard Millet, A New Forage for the Coast Section	3,000	4
81	Electric Water Heaters for Poultry	5,000	15
82	A Method for Testing Moisture in Dried Prunes	3,000	8
83	Drainage and Improvement of White Land and Similar Wet Land	5,000	16
84	The Chemical Composition of Insecticides and Fungicides	1,500	16
85	Green Feed and Pasture for Poultry (in press)	8,000	16

Circulars of information

1924-1926

No.	Name	Pages
1	Harding Grass, by G. R. Hyslop	1
2	Purity Test Information, by E. N. Bressman	1
3	A New Treatment for Moss in Lawns, by G. R. Hyslop	1
4	Weed-killer Formula, by A. L. Peck	1
4	Insects Injurious to Bulbs, by Don C. Mote	3
5	Root Crops, by G. R. Hyslop	4
6	Directions for Starting Alfalfa in the Willamette Valley, by G. R. Hyslop	3
7	Report of Work in Connection With Development of Methods of Applying Dust for Insect Control by the Use of the Airplane, by W. J. Chamberlin	7
8	Stem Rot of Legumes, by H. P. Barss	3
–	Control Measures for Aphids, by Joseph Wilcox	2
9	Save Oregon's Apple and Pear Crop from the Million Dollar Bandit, by Don C. Mote	3
10	Strawberry Crown Borer, by B. G. Thompson	1

1926-1928

11	A Preliminary Report on the Hydrochloric Acid Dipping Process and Its Effect on the Keeping Quality of Fruits, by R. H. Robinson and Henry Hartman	4
12	Timely Warning on Western Army Cutworm—A Wheat Pest, by Don C. Mote	2
13	The Determination of Maturity in Sweet Cherries, by Henry Hartman	7
14	Apply First Codling Moth Cover Spray Now, by Don C. Mote	1
15	The Oregon Fruit Washer, by Henry Hartman, George W. Kable, and R. H. Robinson	5
16	Ladino Clover for Coast and Willamette Valley Sections, by H. A. Schoth	3
17	The Raspberry Fruit Worm, by Don C. Mote (Oct. 1927)	2
18	The Raspberry Fruit Worm, by Don C. Mote (Mar. 1928)	1
19	The Gooseberry and Currant Fruit Fly, by Don C. Mote (Apr. 1928)	2

20 The Effect of Land Plaster Applied as a Dust to Seed Corn, by E. N. Bressman 2
21 The Gooseberry and Currant Fruit Fly, by Don C. Mote (May 1928) 1

SUMMARIES OF PUBLICATIONS

BRIEF summaries of the bulletins and circulars issued during the biennium are presented below, together with brief summaries of articles by members of the Station Staff published during the biennium in the various scientific and technical journals.

STATION BULLETINS

224. **Wintering Stock Steers,** E. L. Potter and Robert Withycombe.

In Station Bulletin 224 is contained a summary of results obtained in wintering stock steers covering a ten-year period. The primary object of the work is to determine satisfactory winter rations for steer calves or yearlings which are to be grazed upon summer range. These rations were made up of home-grown feeds supplemented in some cases with cotton-seed cake. Alfalfa hay (which is doubtless the standard of all such feeding rations), silage, straw, and cotton-seed cake were used.

Calves consumed from 12 to 14 pounds of alfalfa hay without waste and yearlings likewise consumed 20 pounds.

Either barley or oat straw supplemented with 1 pound of cotton-seed cake proved to be a very satisfactory wintering ration.

The addition of silage to the ration increased the gains somewhat, but likewise increased the cost to a point where it became unprofitable for wintering stock steers.

The value of grain in connection with rations for fattening steers has never been questioned. Its use in connection with the winter feeding of stock steers, however, is not recommended.

From the results obtained it is concluded that all gains made while in the winter feed yards are expensive and since the gains made on grass are inversely proportional to those made in the feed yards it would therefore seem to be neither necessary nor desirable to winter stock steers other than in a good, thrifty, growing condition.

225. **The Cranberry in Oregon,** W. S. Brown.

This bulletin deals with the history of cranberry growing in Oregon and the Pacific Northwest and with soils, water supply, clearing, diking, sanding, and other matters pertaining to preparation of bogs for planting. Leading varieties such as McFarlin, Howes, Searles, Centennial, and others are described and relative importance given. Cost of preparing the bog, planting it, and bringing it into profitable bearing is shown. Maintenance of bog, including flooding, control of insects, diseases, and weeds; bearing of yield upon profit; picking, grading, packing, storage; and influence of rainy weather upon quality of fruit are discussed. Marketing and marketing agencies are described.

226. **A Progress Report on the Removal of Spray Residue from Apples and Pears,** R. H. Robinson and Henry Hartman.

Removal of arsenical spray residue from apples and pears below maximum tolerance became an urgent necessity with the season of 1926. Mechanical means, brushing and wiping, proved to be ineffective and more or less harmful to the keeping properties of the fruit. An extended search for a satisfactory solvent resulted in the recommendation of hydrochloric acid to the fruit industry as the most feasible of any of the chemicals tried. This publication is a record of laboratory experiments on which this recommendation is based. Water solutions of hydrochloric acid in concentrations ranging from .25 to .75 percent are effective in removing arsenical and other spray residues and do not in the least injure the storage qualities of the fruit.

227. **Walnut Drying and Packing,** E. H. Wiegand.

A brief comparison on the types of driers used for drying fruit and those adapted to drying nuts is followed by discussion of the bin dehydrator, especially designed for drying walnuts. Investigations carried on have shown that the bin type of drier saves time and reduces the cost of drying. It can be adapted to the remodeled Oregon tunnel recirculation drier. During the time of the experiment, the average cost of drying walnuts under forced circulation of air amounted to $6.25 per ton, which included light, power, water, labor, and fuel, but no overhead charges. Information on bleaching walnuts is given. The bulletin contains general information on grading, bleaching, packing, and storing of walnuts.

228. **Investigations on the Harvesting and Handling of Bosc Pears from the Rogue River Valley,** Henry Hartman, J. R. Magness, F. C. Reimer, M. H. Haller.

The pressure test, as devised by the Agricultural Experiment Station, is the best known means of determining the time of picking Bosc pears. The period during which Bosc pears can be harvested from any one orchard and attain first class quality, appears to vary from ten to fifteen days. Temperature after harvest has material bearing on the storage life and the dessert quality of this variety of pear. For long keeping, immediate storage at 30° to 32° F. is essential. Storage at higher temperatures, such as 40° to 50° F., does not improve the dessert quality and materially shortens the storage life of the pear. While Bosc pears may be kept for considerable periods of time at 30° to 32° F., they do not develop quality unless they are removed from storage while still firm and allowed to ripen at temperatures between 60° and 70° F. The practice of subjecting Bosc pears to a delay of several days prior to storage at low temperatures usually does not improve the dessert quality, and it may materially shorten the storage life. Storage at shipping point appears to be feasible and practical.

229. **Cattle Marketing Investigations at Portland, Oregon,** H. A. Lindgren and E. L. Potter.

A report of findings with following main recommendations:

1. It is desirable to make all beef-bred steers as fat as they can be made on grass or hay regardless of the time of year, but especially for the early summer market.

2. Cattle prices are normally highest in the late spring and lowest in the fall, but the cost of production follows a similar curve so that there is no advantage in crowding unfinished cattle into the higher-price season.

3. The average premium on grain-fed steers over hay-fed steers was only 35 cents, which does not justify the expense of grain feeding.

4. Young steers sell at a satisfactory price providing they are fat.

5. Kill dairy-bred bulls at birth rather than make steers of them.

6. Light steers weighing 950 to 1150 pounds are most desired.

7. Heifers sell at better advantage than thin or low grade steers.

8. Make all beef-bred cows as fat as they can be made on grass. It is a question whether it will pay to fatten them on winter feed.

9. Discarded dairy cows should be sold as soon as possible and no expense put on them.

10. Market all calves before they pass 200 pounds in weight.

11. The variety of territory tributary to Portland makes it possible for the producer to market his cattle when they can be made the fattest and the cheapest.

12. An average of 2,500 cattle per week satisfies the demand at Portland.

230. **Immunity or Resistance of the Chicken to Coccidial Infection,** W. T. Johnson.

Reports investigations which established that:

1. Commercial flock fowls may develop fatal coccidiosis after maturity, but more often possess a high degree of resistance or immunity.

2. Cage-reared fowls may, with few exceptions, be maintained very susceptible to coccidial infection up to and including maturity.

3. A high degree of resistance, if not immunity, may be regularly developed by experimental inoculation.

231. **Electric Lights for Increasing Egg Production,** Geo. W. Kable, F. E. Fox, and A. G. Lunn.

This bulletin gives the results of two years' comparative studies of lighted and unlighted flocks of White Leghorn pullets and hens. They include the effect of lighting on egg production, on feed consumption and costs, on mortality, and on flock profits. Suggestions are also given regarding the use of lights for different purposes and on stock of different ages. Information is given on how to light the laying house, the amount of illumination required, and the cost of installing lighting equipment.

232. **The Eradication of Infectious Abortion from the Dairy Herd of Oregon State Agricultural College,** B. T. Simms, C. R. Donham, F. W. Miller, P. M. Brandt, I. R. Jones, and R. C. Jones.

Reports the methods followed in establishing an abortion-free herd and summarizes the experimental work which made it possible to control and eradicate infectious abortion.

233. **A Study in the Ratios of Assessed Values to Sale Values of Real Property in Oregon,** W. H. Dreesen.

This bulletin reports data and conclusions from the study outlined in the title. The object of the study was to discover any existing inequalities or tendencies in the assessment of real properties in the state, probable causes and effects of such tendencies. The study involved examination of 16,806 rural property transfers and 23,327 city property transfers, aggregating a total sale value of $196,247,341. The assessed value of the real property included in these transfers aggregates an amount equal to 11.22 percent of the total assessed value of all real property for the year 1921.

Variability of the assessments of individual properties is one of the significant findings of the investigation. The amount of taxes misplaced among different valued groups due to inequalities aggregates less than 4 percent, and the ill results therefrom are out of all proportion to the taxes so misplaced. The studies show that 18 percent of all taxes are misplaced, making less than one-half the real property of the state bear two-thirds of the real property levy.

The full text of the bulletin is essential for adequate understanding of the scope and results of the investigation.

234. **The Removal of Spray Residue from Apples and Pears,** R. H. Robinson, Henry Hartman, and S. M. Zeller.

This is a bulletin of three parts.

Part I, by R. H. Robinson. The hydrochloric acid treatment of apples and pears for the removal of spray residue is the most feasible and practical of all methods yet proposed. Certain conditions were noted in 1927, however, that seriously lessened the effectiveness of the acid wash: (1) accumulations of naturally secreted wax, (2) residues of oil-sprays, (3) excessive amounts of arsenicals, (4) coatings of dust and other wind-borne particles that tightly cover the spray applications.

Extensive series of laboratory experiments warrant certain recommendations that growers, especially apple growers, should note. Every effort should be made to pick in season before wax accumulation is extreme. Washing should be made at once, or in case that is impracticable, storage should be made at cold storage temperatures to lessen further development of wax. Where necessary to soften the wax-like coating and render more effective the solvent action of the acid, the temperature of the acid wash solution can safely be increased to 95° F. The use of oil sprays late in the season is to be discouraged. So, likewise, is the application of excessive amounts of arsenicals. The use of either calcium carbonate or slaked lime in the spray mixture seems to lessen very materially the retarding effect of coatings of dust and other wind-borne particles on the effectiveness of the acid wash.

Part II, by Henry Hartman. More or less injury invariably follows the application of mechanical methods (wiping or brushing) for the

removal of spray residues from apples and pears. The injury is more noticeable on pears. Because of skin puncturing or abrasure, the keeping quality is very materially lessened. Of the many solvents available for the removal of spray residue, dilute solutions of hydrochloric acid stand among the most effective and are believed to be the most practical of all. Approximately 3,000 observations have been made on lots of apples and pears variously treated for the removal of spray residue, to note the effect of the treatment upon keeping qualities. The acid wash, properly applied, increases rather than diminishes the keeping properties of both apples and pears. There are certain dangers, however, in the use of the acid wash solution which must be noted and avoided, particularly in the treatment of apples. The principle of submersion is not generally applicable in the washing of apples because of the danger of core penetration by the acid solution. Quick decay follows storage in which there is an accumulation, however slight, of the acid solution in the more or less open cores. This danger of decay is obviated by shallow flotations during the washing process and the use of spray washing. Washing by any method must be followed by thorough rinsing with water in order to remove all traces of acid; otherwise, there is danger of acid burn and quick decay in storage. Perfect drying of the fruit following the rinsing process is not absolutely essential to good keeping under storage conditions.

Part III, Henry Hartman and S. M. Zeller. The use of various disinfecting agents in the acid wash on a laboratory scale pointed to the feasibility of formaldehyde. Its use, however, under commercial conditions has proved to be less feasible than was at first anticipated. No definite recommendations can yet be made of suitable combinations of disinfecting agents and the acid wash. It is to be noted that the hydrochloric acid solution and the rinse water mechanically remove most of the infectious spores.

235. **Economic Limit of Pumping for Irrigation,** W. L. Powers. (In press.)

Twenty years' experiments with supplemental irrigation with staple crops in typical Willamette Valley soil indicates that it will pay to pump 25 to 40 feet for alfalfa, something like twice this lift for potatoes, and still greater lifts for certain small fruits. The factors affecting the probable economic limit include the amount of lift, size of pump, cost of energy, efficiency of the pumping unit, care and use of the irrigation water, amount and value of crop increase, and quantity of water required. Crop rotation and manure are found to be especially valuable in obtaining economic returns from pumped water.

236. **Field Crops for Pump Irrigation at the Harney Branch Experiment Station,** Obil Shattuck and R. E. Hutchinson. (In press.)

Yields of winter and spring cereals, alfalfa, field peas, and potatoes under irrigation are presented. Duty-of-water trials on Federation wheat, with and without rotation, and on wheat, field peas, alfalfa, potatoes, and sunflowers with rotation show moderate applications of water to be most economical. Fertilizer trials with those crops do not generally make significant increases on these lands that are relatively new. Practical

suggestions to pump irrigators are made. Detailed climatic data are presented.

Soil Survey Report of Linn County, Oregon (in press), A. E. Kocher, in charge, and E. J. Carpenter, United States Department of Agriculture, Bureau of Soils, and K. S. Taylor, Oregon Agricultural Experiment Station.

One of the series of cooperative soil reports; describes the topography, climate, agriculture, and soils of Clackamas county, soil characteristics, physical and chemical composition, crop adaptation; methods of improvement or utilization are outlined. The area outside the National Forest is surveyed and includes 623,360 acres, which is divided into 23 soil series, including 30 distinct soil types. The report includes a colored map showing the location and extent of each soil type and all important landmarks, such as trees, roads, houses, and fences.

Soil Survey Report of Polk County, Oregon, E. F. Torgerson, in charge, and Charles Hartmann, Jr., Oregon Agricultural Experiment Station; E. J. Carpenter and W. G. Harper, U. S. Bureau of Soils.

The area surveyed outside the National Forest in Polk county is 476,160 acres, including 16 soil series and 23 distinct soil types. The map shows the location and extent of these soil types, while the report describes their physical and chemical characteristics, crops adapted to them and methods of improvement.

Soil Survey Report of Linn County, Oregon, (in press) A. E. Kocher, in charge, E. J. Carpenter, and W. G. Harper, of the U. S. Bureau of Soils; E. F. Torgerson and R. E. Stephenson, Oregon Agricultural Experiment Station.

This survey covers all land outside the National Forest in Linn county, and the extent and location of each of the 13 soil types recognized will be shown on a colored map with a scale of one square inch to one square mile. The soils are grouped in 30 series and three divisions. The area surveyed is approximately 1,022,250 acres.

Soil Survey Report of Lane County, Oregon (in press), E. J. Carpenter, in charge, and Arthur Albin, U. S. Bureau of Soils, and V. D. Young, Oregon Agricultural Experiment Station.

This is similar to the survey of Clackamas county above described, dividing Lane county soils into 15 series of 31 distinct types, which are represented on a colored soil map, and described in the report to be printed. The series are classed into four groups, the total area mapped being 820,160 acres.

Soil Survey Report of Marion County, Oregon (in press), E. F. Torgerson, in charge, Oregon Agricultural Experiment Station, and T. Glassey, U. S. Bureau of Soils.

Area surveyed 557,440 acres divided into 23 soil series and 44 distinct soil types. Location, extent, characteristics, and methods of improvement and utilization described or mapped.

Soil Survey Report of the Grande Ronde Valley, Oregon (in press), A. E. Kocher, U. S. Bureau of Soils, in charge, and Arthur Albin, Oregon Agricultural Experiment Station.

The Grande Ronde soil survey covers an area of more than 205,000 acres, which includes four divisions and 12 soil series, and some 32 distinct soil types. The location, extent, characteristics, and methods of improvement are described and represented on a colored map. The 7 soil types best suited to irrigation belong to Paloose, Walla Walla, and La Grande series, and include 20,500 acres. Five soil types belonging to Paloose, La Grande, and Cattrine series suited to supplemental irrigation include 20,150 acres. Seven wet soil types belonging to Nibley, Willow, and Imbler series need drainage and occupy an area of 39,400 acres.

The following completed reports not published:

Drainage Reconnaisance of Grande Ronde Valley, Oregon, T. C. Adams.

Report is made of the cooperative drainage study participated in by the Oregon Agricultural Experiment Station and the United States Department of Agriculture, Division of Agricultural Engineering. The early development of drainage courses and the extent of wet areas and means of affording relief are reported from a study of topography, water-table, alkali, vegetation, and subsoil conditions. Three classes of wet land include (1) lands affected by foot-hill seepage and subject to improvement by intercepting with individual outlet ditches, (2) lands subject to overflow and to improvement through better outlets, straightening of channels, dike improvement, storage, and possibly by pumping for drainage, (3) the water-logged and alkali land in the Valley floor would require deep drainage, chemical treatment, copious irrigation, and alkali-resistant crops for improvement. The most promising areas are those northwest of Union, northeast of Hot Lake, and southwest of Lone Tree. For the flatter areas the possibility of drainage by means of pumping needs further study. Any unit of construction should be planned so as to fit into a general relief plan for the whole system eventually.

Economic Irrigation Studies in Rogue River Valley, Charles Hartmann, Jr., and Herman McCormack.

Results of studies during the summer of 1925 for determining economic methods of clearing, fitting, and applying water to soils of coarse texture, especially near Grants Pass, and to adobe soils in the vicinity of Medford have been summarized. On coarse soils such as granitic or Siskiyou sandy loam it is found desirable to use strip borders with strong borders, and to use a head of from two to three cubic feet per second, which make it possible to apply a four- or five-inch irrigation to meadow land on this soil. Formerly as much as eight inches was applied at one irrigation, whereas the usable water capacity of the soil profile is about four and one-half inches, according to tests made. In contrast to this is the method worked out for applying irrigation to the heavy adobe soils near Medford. The half-inch stream applied to furrows in the orchards there is required to run twenty-four to thirty-six

hours in order to insure penetration into the surface foot. One thousand three hundred and twenty feet is not too far to run water in this heavy, flat land. Sweet clover, Hungarian vetch, and barnyard manure have been active in increasing the absorptiveness of this heavy soil where it has been difficult to obtain penetration below two feet. These treatments have resulted in a better size and yield of fruit. Light, frequent irrigation on Columbia fine sandy loam applied by the strip border method has been found desirable to avoid drainage trouble where this land has a shallow water-table. Cost of land and clearing and fitting it so as to bring it into full production under irrigation is summarized for two dozen farms. These costs bring the price of improved land to $200 and $300 per acre in the Grants Pass section, where land has been improved under recent conditions.

Soil, Agricultural, Economic, and Engineering Feasibility Reports on Ochoco Irrigation District, W. L. Powers, W. W. McLaughlin, and M. H. Lapham, Dec. 1926.

Ochoco Supplemental Report, A. A. Young and R. E. Stephenson, April, 1928.

At the request of the Oregon Reclamation Commission and the State Securities Commission, the Oregon Agricultural Experiment Station, after obtaining the cooperation of the experts from the U. S. Bureau of Soils and Division of Agricultural Engineering of the United States Department of Agriculture, undertook studies of the Ochoco and other projects. The original Ochoco survey included a soil survey and economic study to determine the probable productive value of the land irrigable with the water supply available, also the physical condition of the structures, and developed plans for rehabilitation of the project, together with a general determination of the probable salvage value. The supplementary report classified the land in detail according to its productive value and included an appraisal of the number of irrigable acres in each class for each forty-acre tract.

Agricultural, Economic, and Engineering Phases of the Warm Springs Irrigation Project, W. L. Powers, W. W. McLaughlin, and P. A. Ewing, Sept. 1927.

For the field work connected with this report the cooperation of W. W. Johnston, of the U. S. Bureau of Reclamation, and the assistance of Dr. R. E. Stephenson, of the Oregon Agricultural Experiment Station, were obtained in addition to the authors named. The report contains a detailed soil classification map and results of economic and engineering studies, which bring out the proper salvage value of the project based on productive value of the agricultural land and the water resources of the project, together with recommendations for rehabilitation of the project.

Agricultural, Economic, and Engineering Phases of the Grants Pass Irrigation District, W. L. Powers, W. W. McLaughlin, and P. A. Ewing, June, 1928.

This report contains the classification of soils made in the field by R. E. Stephenson, of the Oregon Agricultural Experiment Station, re-

sults of studies of the water rights and irrigation ditches by C. Stricklin and the project manager, as well as description of the topography and drainage conditions, cost and methods of clearing and leveling, climate, types of farming, extent of production, market and transportation conditions, farm indebtedness, land tenure, valuation, tax assessment rates, estimates of productiveness of agriculture, and possibilities of crop expansion; a land settlement program, rehabilitation plans for the irrigation system, and recommendations or plans of refunding of district indebtedness, as well as recommendations for annual crop census and cost of production studies.

STATION CIRCULARS

77. **Hessian Fly,** L. P. Rockwood.

Serious injury to wheat occurs in Western Oregon in certain years when conditions are favorable to a maximum increase of the Hessian fly. This circular is a brief statement of the life-history and habits of the Hessian fly and recommendations for its control under Oregon conditions.

78. **Commercial Fertilizers** (1927 Edition), R. H. Robinson.

This circular results primarily from the enforcement of the state law governing the sale of commercial fertilizers. A brief discussion is given of the forms in which various elements of plant food occur in commercial fertilizers available in Oregon. Methods based upon analytical data are given for calculating the commercial value of fertilizers, and finally a tabulation is given of "found" and "guaranteed" analyses.

79. **Strawberry Root-Weevils and Their Control in Oregon,** Don C. Mote and Joseph Wilcox.

The Strawberry Root-Weevils constitute one of the worst menaces to the strawberry industry in Oregon. There are three common species and two other less common but even more damaging species in Oregon. Experiments made during the 1926 season have shown that:

A home-made bait made of 95 pounds of ground dried apple mixed with 5 pounds of powdered poison and the commercial bait "Go-West" will kill the adults of the Strawberry Root-Weevils.

Calcium arsenate is the most effective poison and is the poison recommended to use in the home-made baits.

The bait is best applied at the rate of from a teaspoonful to a tablespoonful to a hill directly in the crown of the plant.

The time to make the first application of the bait is when about 75 percent of the weevils have changed to the adult stage.

Applications of the bait at this time will kill the weevils before they lay their eggs.

80. **Japanese Barnyard Millet,** A. E. Engbretson.

This circular deals with the most important factors necessary in obtaining desirable results in the growing of Japanese Barnyard Millet, a

new forage crop for the Coast section of Oregon. The varying results obtained by different farmers in their first trials indicate the necessity of definite information in the growing of this crop. The crop is of value as a soiling crop for August and September feeding. When successfully grown a yield of 12 to 15 tons can be expected. Under extremely favorable conditions yields of 20 to 25 tons are not uncommon.

The crop is most exacting in its seed-bed requirements. The land must be free of weeds. Deep planting is a common mistake; an application of barnyard manure is most necessary to obtain a good crop; the crop will not grow on poor land; the rate of planting is 25 pounds per acre.

81. **Electric Water Heaters for Poultry,** George W. Kable and F. E. Fox.

Various types of suitable electric heaters are described in this circular. Recommendations are made relative to the size of heaters and different climatic conditions and different sized containers. Water consumption in flocks of White Leghorn pullets was increased 5 percent by warming the water during average Western Oregon winter weather, and 25.4 percent during freezing weather. Pullets consumed .26 pound of water per day and 44 pounds of water per 100 eggs laid.

82. **A Method for Testing Moisture in Dried Prunes,** E. H. Wiegand and D. E. Bullis.

Testing moisture in prunes by a distillation method using toluene is described. The method is accurate enough for all purposes of practical work. A special tube has been designed, reading percentages direct, so that no calculation is necessary on the part of the operator. It is possible to make a determination of moisture in 30 minutes, whereas the usual laboratory method takes from 4 to 12 hours.

83. **Drainage and Improvement of White Land and Similar Wet Land,** W. L. Powers.

This circular describes the characteristics of "white land" or Dayton silty clay loam, and reports experiments which have worked out fairly definitely the depth, distance apart, and size of tile drains, as well as the methods of fertilization and improvement of tiled white land to aid in obtaining economic returns following drainage. Directions are given for the installation of tile drainage systems and structures and the results of fertilizer experiments and studies with drainage tanks for observing the rate and amount of percolate and the plant food contained in drainage water. The circular summarizes the best information accumulated on the utilization of soils of the Dayton series.

84. **The Chemical Composition of Insecticides and Fungicides,** R. H. Robinson and C. F. Whitaker.

This publication reports the chemical analysis of various spray materials collected in carrying out the provisions of the Oregon Economic Poisons Law. To aid in imparting an understanding of the nature of spray ingredients, the quality and requirements of the different classes

are discussed previous to the tabulations of "found" and "guaranteed" compositions.

85. **Green Feed and Pasture for Poultry,** H. A. Schoth. (In press.)

A discussion of the production and utilization of green feed and pasture crops for different sections of Oregon that poultrymen may provide adequate supplies of green feed, pasture, or winter succulence at reasonable cost. Grains, grasses, vetches, alfalfa, clovers, kale, cabbage, rape, corn, and root crops are discussed. Cropping systems to provide continuous green feed for the different sections are presented.

REPORTS PUBLISHED IN TECHNICAL JOURNALS

A Canker of Apple and Pear Trees Caused by Glutinium macrosporum n. sp., S. M. Zeller, Jour. Agri. Research, 34:489-496. illus. 1927.

This paper describes a new species of *Glutinium* which has been found occurring on the bark of apple and pear trees in Western Oregon. When inoculated into the bark of the pear, the fungus proved to be a wound parasite developing a bark canker which extended into the wood beneath. The morphology of the fungus on the host, and cultural and spore germination characteristics on artificial media are described. A fruit rot of apple is produced by artificial inoculation with the organism which has been called *Glutinium macrosporum* Zeller.

The Yellow Rust of Raspberry Caused by Phragmidium imitans, S. M. Zeller, Jour. Agri. Research, 34:857-863. illus. 1927.

This rust disease is described. The geographic distribution and life-history as observed on the Cuthbert red raspberry in the Northwest Coast states is given, with particular reference to the uredinial lesions on the stems. Infections of new canes near the ground line became serious the second year (on fruiting canes), since the resulting cankers produce brittleness and diminish sap-conducting tissues. Thus canes are easily broken in trellising, and the rise of sap may be insufficient for complete maturity of the fruit.

No satisfactory means of control are known, but extreme sanitary methods for the elimination of old leaf and cane refuse are the most practical methods suggested.

Preliminary Studies on Witches' Broom of Strawberry, S. M. Zeller, Phytopathology, 17:329-335. illus. 1927.

Witches' broom of strawberry is characterized by a dwarfing of the whole plant, spindliness of petioles, and an arching downward of the margins of the leaflets, which are lighter in color than in normal plants. Runners are shortened, the baby plants with symptoms like those of the mother plant taking root near the parent.

When this paper was published, witches' broom had been found in Western Oregon only, but in the summer of 1927 it was observed in Eastern Washington and Western Idaho. It has been observed on the varieties, Marshall, Nick Ohmer, Oregon, and Ettersburg 121. Experi-

ments show the disease to be transmitted by viruliferous leaf lice (*Myzus fragaefolii*).

A Correction. S. M. Zeller, Mycologia, 19:150-151, 1927.

Since W. A. Archer, of the U. S. Bureau of Plant Industry, has found that *Coryneum ruborum* Ond. is identical with the organism causing the Hendersonia cane spot of raspberries in Europe known under the older name of *Hendersonia rubi* Westendorp, the name of the perfect stage (Mycologia 17:33-41, 1925) is changed from *Ascospora ruborum* (Ond.) Zeller to *A. rubi* (Westendorp) Zeller.

Dwarf of Blackberries, S. M. Zeller, Phytopathology, 17:629-648. illus. 1927.

The dwarf disease of the vining type of blackberry (dewberry), represented especially by the logan and phenomenal varieties, was recognized in the Pacific Coast states as early as 1918. The disease occurs wherever the phenomenal berry is grown and also infects the loganberry, Cory's Thornless, and the Kittitany blackberry. It is most widespread where loganberries and phenomenal berries are grown commercially, i. e., from British Columbia south to central California. The economic importance of the disease is measured by the number of plants affected, for a plant which has had dwarf for one full season is valueless thereafter. Some growers of phenomenal berries have reported as high as 100 percent of the plants affected by the third year in plantings which have not been rogued. One planting of loganberries with 19 percent of diseased plants in the third year has been found. As a rule, the loss through dwarf to the loganberry industry in Pacific Coast states is very slight, but many individual growers have experienced high enough percentages to make total eradication necessary.

Dwarf is characterized in its severe stages by short, stubby canes, the internodes of which are very short; the whole cane has a very leafy appearance. The leaflets are smaller and more rounded and are lighter in color than normal, showing a finely netted, uniform mottling. The fruit develops to a fair size, but the druplets easily fall apart, becoming a crumbly mass in the boxes. Tips of canes do not readily take root when layered, and it is believed the disease would soon be self-exterminating if there were not other means of transmission. The dwarf disease is one of the infectious virus diseases as demonstrated by transmission experiments in which a mixed colony of aphis (*Capitophorus tetrarhodus* and *Macrosiphum dirhodum*) found on the wild sweet-briar rose, *Rosa rubiginosa,* were the agents of transmission. On the other hand, experiments with the snowy tree cricket (*Oecanthus niveus* De Geer) and leaf hoppers (probably *Empoa rosae*) resulted in no transmission. Juice expressed from macerated diseased leaves was injected into healthy plants in several ways with no resulting disease. When buds from diseased plants were grafted into healthy plants no disease resulted. Environmental changes have had little influence on symptoms of dwarfed plants.

Dwarf of blackberries has some symptoms in common with such other virus diseases of brambles as the streak and yellow mosaic of black raspberries and the expression of red raspberry mosaic when in-

fecting black raspberries. On the other hand, most of the symptoms of dwarf differ from those of other virus diseases of brambles.

Preventive measures are (1) to obtain stock from plantings which are free from dwarf and (2) to discourage the use of the phenomenal blackberry as a commercial or home garden variety in districts where the loganberry is a desirable commercial product. Plantings with small percentages of dwarf, five percent or less for instance, may be rogued of the diseased plants with practical results.

Since this paper was published dwarf has been transmitted by the aphis, *Amphorophora rubi,* which has been found on the Himalaya blackberry in several locations in the Willamette Valley.

Hysterangium in North America, S. M. Zeller (with C. W. Dodge, of Harvard University), in press—Annals Missouri Botanical Gardens.

A monograph which covers more than 30 species of this genus for the world.

TECHNICAL PAPERS

Potassium in Animal Nutrition. IV. Potassium Requirements for Normal Growth and Maintenance, H. G. Miller, Journal of Biological Chemistry, Vol. LXX, No. 2, Oct. 1926.

In continuation of previous studies in which rats were used as experimental animals, it was found that the minimum daily potassium requirements for normal growth in the male is approximately 15 mg. For the female, it was found to be approximately 8 mg. The male apparently requires more potassium than the female for purposes other than increase in body weight. The daily maintenance requirement of a mature animal for potassium is not more than 2 mg. Based on the potassium requirement for this type of animal and the content of potassium in natural food stuffs, the potassium requirements for animal development are abundantly satisfied in the ordinary rations.

Potassium in Animal Nutrition. V. Influence of Potassium on Urinary and Fecal Excretion of Sodium, Chlorine, Calcium, and Phosphorus, H. G. Miller, Journal of Biological Chemistry, Vol. LXX, No. 2, Oct. 1926.

This is the final paper of this series dealing with potassium in animal nutrition. As heretofore, the rats were the experimental animals. The increased excretion of sodium and chlorine caused by increasing the potassium intake of the rats, is found entirely in the urinary content of sodium and chlorine. Sodium excretion was persistently higher during the period of high potassium intake. The amounts of potassium fed were abnormally high, but did not retard growth or cause continued excretion of chlorine, phosphorus, and calcium.

Vitamine B Requirement for Successful Reproduction and Rearing of the Young, H. G. Miller, Journal of Biological Chemistry, Vol. LXXIX, No. 2, January, 1927.

The percentage of Vitamine B in a ration satisfactory for successful gestation and lactation need not be greater than in a ration supporting normal growth.

Facilitating the Removal of Spray Residue, R. H. Robinson, Journal of Economic Entomology, 1928. (In press.)

The hydrochloric acid wash solution is the most feasible of all methods yet proposed for the removal of spray residues from apples and pears. Certain conditions, however, met with here and there lessen its effectiveness. These laboratory experiments point to procedures believed to be practical in overcoming the conditions noted.

The Value of Nitrification Tests When Used on Soils Representing Extreme Contrast in Physical and Chemical Properties, W. V. Halversen, Soil Science. (Accepted for publication.)

Standardized methods for determining the nitrifying powers of soils have often been the subject of severe criticism. In this study of soils representing extreme contrast in physical and chemical properties it was found that by using four methods simultaneously, a very close agreement could be obtained on normally productive soils of varied cropping and fertilizer treatment, but when these same methods are used on light, sandy, arid soils of low buffer capacity the results are inconsistent. The lack of conformity of the results obtained on light, sandy soils is probably due to lack of residual effect of the fertilizers added and lack of buffer capacity.

The Microchemical Demonstration of Phloridzin, E. M. Harvey.

An invitational paper read before the American Society of Plant Physiologists in Philadelphia, December 28, 1926.

It describes the working out of new microchemical methods for the determination of phloridzin.

The Function of Glucosides in Plants, E. M. Harvey.

Paper read before the joint meeting of the American Society of Plant Physiologists, American Society of Horticultural Science, and the Physiological Section of the American Botanical Society, in Philadelphia, December 30, 1926.

This paper describes the study of responses of apples to various anaesthetics in regard to the alteration of their phloridzin content.

The Winter Behavior of Phloridzin in the Apple Tree, E. M. Harvey.

A paper presented before the Biology Club of Oregon State Agricultural College, November 1927.

Studies Relating to the Harvesting and Storing of the Bosc Pear from the Rogue River Valley, Henry Hartman, Proceedings of the Oregon State Horticultural Society, 1926.

A preliminary report issued at the end of the first year's work.

Removal of Spray Residue from Apples and Pears, Henry Hartman, Better Fruit, Jan. 1927.

The Relation of Spray Residue Removal to the Keeping Quality of Apples and Pears, Henry Hartman, Better Fruit, June, 1928.

Sterility in Filberts, C. E. Schuster.

Invitational paper sent to International Conference on Sterility, meeting in New York City, July, 1926.

The paper stated that filberts are self-sterile but rarely intersterile in the group composed of *Corylus Avellana, C. pontica,* and *C. maxima.* Sterility exists between the cultivated filberts in the above group and the species *C. Colurna* and *C. californica.* The Barcelona is the main commercial variety and is regularly pollenized by Daviana, Du Chilly, White Aveline, and Nottingham.

Peppermint Growing for Oil in the Pacific Northwest, A. G. Bouquet, 19th Bien. Rept. Ore. State Board of Hort., pp. 104-105, 1927.

Vegetable Insect Control Chart, A. G. Bouquet, D. C. Mote, and M. B. McKay, American Produce Grower, May, 1928.

Vegetable Irrigation, A. G. Bouquet, Better Fruit, June, 1928.

Pollination of Greenhouse Tomatoes, A. G. Bouquet, American Produce Grower, March 1927.

Review of the experimental work in pollinating tomatoes so far carried out at the Oregon Agricultural Experiment Station.

Seasonal Factors Influencing Cut-outs, E. H. Wiegand, Annual Meeting Northwest Canners' Association, 1927.

Report of some of the experimental work bearing upon this subject done at the Oregon Agricultural Experiment Station.

Maturity a Factor in Grading, E. H. Wiegand, Annual Meeting Northwest Canners' Association, 1928.

This paper incorporated some of the results of the experimental work of 1927 on cherry grading for maturity.

Progress of Prune Standardization, E. H. Wiegand, North Pacific Prune Exchange Annual Meeting, March, 1928.

Economic Aspects of Fruit Production in Oregon, W. S. Brown, Oregon State Bankers' Conference, January 23, 1928.

Nitrogen Metabolism of Nitrogen-Fixing Bacteria, W. V. Halversen, Iowa State College Journal of Science, Vol. I, No. 4, pp. 395-410, July, 1927.

Production of Artificial Farmyard Manure by Fermenting Straw, W. V. Halversen and E. F. Torgerson, Journal of the American Society of Agronomy, Vol. 19, No. 7, pp. 577-584, July, 1927.

Seasonal Variation of Nitrates in Willamette Valley Soils as Influenced by Liming and Cropping, W. V. Halversen, Journal of the American Society of Agronomy. (Accepted for publication.)

This paper presents data showing that no excess of nitrates can be found under cereals growing on Willamette silty clay loam irrespective of fertilizer treatment. Lime, however, does favor nitrate formation in fallow plots of the same soil type, but is not sufficient to predict favorable response on growing crops because climatic factors which affect the moisture and temperature relationships of the soil may mask the results.

Observations on the Life History, Habits and Control of the Narcissus Bulb Fly, Merodon equestris Fab., in Oregon, Don C. Mote and J. Wilcox, Journal Economic Entomology, Vol. 20, No. 5, pp. 709-714. October, 1927.

The narcissus bulb fly, *Merodon equestris* Fab., has been introduced into Oregon from Europe and has established itself in the commercial plantings of narcissus.

All larvae in the bulbs can be killed by the hot water treatment as applied for the stem nematode, *Tylenchus dipsaci* Kuehn. This treatment is not a cure-all, however, as it is impossible to remove all the bulbs from the soil when digging. Tests with ovicides made in the spring of 1926 were promising; 100 percent control was obtained with corrosive sublimate.

The Natural "Cleaning Up" Habit of Insects, Don C. Mote, J. Wilcox, and Earl G. Davis, Journal Economic Entomology, Vol. 19, No. 5, pp. 745-748, October, 1926.

This paper calls attention to the habit of certain insects of passing their legs and antennae between their mouth parts and the removing of powdered materials in this manner. This habit of the insects the writers have termed the natural "cleaning up" habit of certain insects. The following insects have been stimulated to this natural "cleaning up" habit in our experiments: *Diabrotica soror, Blatella germanica, Forficula auricularia, Syneta albida,* and *Criocerus asparagi.* Several of the following dusts have stimulated the "cleaning up" with each of the above insects: sodium fluoride, calcium arsenate, lead arsenate, sodium fluosilicate, wheat flour, and powdered milk sugar. The methods used in the experiments are briefly explained.

The Lesser Bulb Fly, Eumerus strigatus Fallen, in Oregon, J. Wilcox, Journal Economic Entomology, Vol. 19, No. 5, pp. 762-772, October, 1926.

The lesser bulb fly, *Eumerus strigatus* Fallen, was first reported from Oregon in 1918. This pest is now established in the commercial onion and narcissus producing sections of the state. Brief descriptions of the various stages are given.

This pest can be partly controlled by the hot water treatment as applied for the stem nematode, *Tylenchus dipsaci* Kuehn. Sanitation is of value in the control of this pest. Corrosive sublimate and white oil emulsions applied as ovicides in the spring show promise of being practical methods of control for this insect.

The Peach and Prune Root-Borer Injurious to Cherries, B. G. Thompson, Journal Economic Entomology, Vol. 19, No. 5, pp. 779-780, October, 1926.

Notes on the injury, life-history, and parasites.

Aegeriidae or Clear-Wing Moths Occurring in Oregon, B. G. Thompson, 19th Bien. Rept. Ore. State Board of Hort.

Some of the most important insect pests occurring in Oregon belong to this family. The Western peach and prune root borer, the loganberry crown-borer, the strawberry crown-borer, and the currant cane-borer are the most destructive species.

A short sketch of the characteristics of the adults, pupae, and larvae and a description of the eleven species occurring in the state are given.

Dormant and Delayed Sprays, Don C. Mote, Pacific Homestead, February, 1927.

Insect Pests of Nursery Stock, Don C. Mote, 19th Bien. Rept. Ore. State Board of Hort., pp. 120-124, 1927.

Narcissus Bulb Flies and Their Control in Oregon, J. Wilcox, 18th Report State Horticultural Society. 1926.

Codling Moth Attacks Cherries, Don C. Mote, Journal Economic Entomology, Vol. 19, No. 5, pp. 777-778, October, 1926.

Narcissus Bulb Flies and Their Control in Oregon, J. Wilcox, 19th Bien. Rept. Ore. State Board of Hort., pp. 149-159, 1927.

What You Ought to Know About the Narcissus Bulb Flies in the Northwest, J. Wilcox and Don C. Mote, Florists Exchange, October, 1926.

Insect Pests of Walnuts and Filberts in Oregon, Don C. Mote, 13th Annual Meeting Western Nut Growers Assn., December 7-8, 1927.

A Suggestion as to How Phytophagous Insects May Ingest Powdered Poison, J. Wilcox, Journal Economic Entomology, Vol. 19.

Insect Pests of Walnuts and Filberts in Oregon, Don C. Mote, Oregon Farmer, May 3, 1928.

Narcissus and Tulip Diseases, M. B. McKay, 18th Annual Report, Oregon State Horticultural Society, pp. 137-150, Dec. 1926.

The Nematode Disease of Narcissus, M. B. McKay, 19th Bien. Rept. Oregon State Board of Hort. 159-168, 1927.

Curly Top, a Disease Affecting Beets, Beans, Tomatoes, Squash, and Many Other Crops, Spread by a Leaf Hopper, M. B. McKay, Seed World, June, 1928.

The Resistance of Certain Varieties of Winter Wheat to Artificially Produced Low Temperatures, Donald D. Hill and S. C. Salmon, Jour. Agri. Research, Vol. 35, No. 40, pp. 933-935, November 15, 1927.

Two Species of Thrips Injurious to Apples in the Pacific Northwest, Leroy Childs, Journal Economic Entomology, Vol. 20, No. 6, December, 1927.

Spraying in full bloom with nicotine sprays reduces injury but does not give complete control.

The Spray Situation, Leroy Childs, 19th Annual Report, Oregon State Horticultural Society, p. 76, 1927.

Perennial Canker of Apples, Leroy Childs, 19th Annual Report, Oregon State Horticultural Society, p. 108, 1927.

Complete Spray Calendar for 1928, Leroy Childs, Better Fruit, Ferruary, 1928.

Stock, Varieties, Methods, and Advantages of Top-Working, Gordon G. Brown, 19th Annual Report, Oregon State Horticultural Society, December, 1927, p. 40.

Progress of Sulfur Investigations, W. L. Powers, Oregon Farmer.

Crop Insurance by Drainage, W. L. Powers, Pacific Homestead.

Utilization of Wet Land, W. L. Powers, Pacific Homestead.

Efficient Designs for Tile Drainage Systems, W. L. Powers, Oregon Farmer.

Soils of Oregon, W. L. Powers, Union Pacific R. R. Publication.

Water Requirements of Pears, W. L. Powers, Oregon State Hort. Society Report, and Reclamation Era.

Water Shortage and Water Economy, W. L. Powers, Oregon Farmer.

Utilization of Alkali Land, W. L. Powers, Oregon Farmer.

Border-Strip Irrigation for Sandy Soils, W. L. Powers, Am. Soc. Ag. Eng. Rpt.

Economic Limit of Irrigation, W. L. Powers, Rural Electric Service School, and Pacific Homestead.

When Orchard Soils Need Doctoring, W. L. Powers, Better Fruit, January, 1928.

Scappoose Drainage District, W. L. Powers, Hydraulic Engineering, 1928.

Irrigation and Drainage Investigations in Oregon, W. L. Powers. Western States Irrigation Conference, Berkeley, January, 1928.

Soil Solution in Relation to Irrigation Requirement of Plants, W. L. Powers, Western States Irrigation Conference, Berkeley, January, 1928.

Established Information on Use of Fertilizers.

Station Soils Committee, Northwest Fertilizer Conference, Corvallis, February 6, 1928.

Needed Information on Use of Fertilizers.

Station Soils Committee, Northwest Fertilizer Conference, Corvallis, February 6, 1928.

Coyote Susceptible to Salmon Poisoning, C. R. Donham and B. T. Simms, Journal of American Veterinary Medical Association 71:215, May, 1927.

Experiments proved coyotes (*Canis lestes*) are susceptible to salmon poisoning and that they develop lesions similar to those in dogs dying from this disease.

A Treatment for Liver Fluke Infestation in Goats, J. N. Shaw and B. T. Simms, Journal of the American Veterinary Medical Association 71:723, September, 1927.

Carbon tetrachloride in doses of one cubic centimeter was found to be a satisfactory treatment for liver fluke infestation in goats.

Two Basic Factors in Coccidial Infection of the Chicken, W. T. Johnson.

Paper read before the American Veterinary Medical Association at Lexington, Kentucky, 1926.

Includes data which establish that the number of sporulated oocysts ingested determines the severity of coccidiosis and that the disease runs a limited course.

Avian Coccidiosis Studies, W. T. Johnson.

Paper read before Third World's Poultry Congress, Ottawa, Canada, 1927.

Irrigation of Small Fruits and Vegetables, Geo. W. Kable, 18th Annual Report, State Horticultural Society, pp. 25-38, 1926.

Results of Research in Feed Grinding, Geo. W. Kable, Agricultural Engineering, 8:53-54. 1927.

A Remote Control for Anemometer, Geo. W. Kable, Agricultural Engineering, 8:108. 1927.

Electrically Heated Chicken Brooders, Geo. W. Kable, Agricultural Engineering, 7:376-378. 1926.

Results From Artificial Lighting of Laying Houses, Geo. W. Kable, Agricultural Engineering, 7:304. 1926.

Low Cost Rural Construction, Geo. W. Kable, Electrical World, 91:1015-17. May, 1928.

What About the Electric Hay Hoist, Geo. W. Kable, Electricity on the Farm, 1:11-12. February, 1928.

Nutrient Requirements of Fiber Flax, W. L. Powers, Journal of the American Society of Agronomy, 20:755-763, 1928.

Flax fiber value increases greatly with length. In a study of the possibility of increasing length and value of fiber flax, fertilizers and supplemental irrigations were employed in field trials, soil pots, cultures, and water cultures.

Early planting, irrigation, potassium increased the length, strength, and percentage of flax fiber.

Effect of Hydrogen-Ion Concentration on the Growth of Certain Plants, W. L. Powers, Soil Science 24:1-7, 1927.

A study was made of effect of reaction on several plants under controlled conditions. In each case best growth occurred in a slightly acid medium. Alfalfa grows best at pH 5.6 to 6.0; Hungarian vetch at pH 5.3; mint at pH 6.0; Alsike clover at between pH 5.5 and 6.0; rhododendrons at pH 5.0. Most nodules developed on alfalfa at pH 6.0 to 7.0, while the largest yield of legumes was obtained at pH 5.2 to 6.5, the range being wider for alfalfa than for alfalfa bacteria. Reaction appeared more important than small amounts of aluminum for rhododendrons. Production of carbon dioxide by rotation tends to maintain a fairly acid reaction. Optimum reaction for plant studied when grown in field or soil plots corresponded to the best reaction in culture solutions. Full advantage should be taken of soil reaction range in which resistant crops grow in the utilization of acid soils.

The Crop-Producing Power of Limited Quantities of "Essential" Plant Nutrient, Charles Hartmann, Jr., and W. L. Powers, Soil Science 25:371-378.

In a study of the dry matter produced by limiting one so-called "essential" nutrient, it was found that nitrate ion affected the yield of

dry matter per milligram most. About twice the yield per milligram was made from economic additions of nitrate as was the relative production with other important fertilizer constituents such as phosphate and potassium. Formation of dry matter per milligram magnesium ion is comparatively low for the conditions of the experiment. The greatest economic growth of alfalfa plants occurred with the addition of about two parts per million phosphate, magnesium, and potassium. A greater concentration of calcium is necessary for the first substantial amount of growth than for other "essential" nutrients and continues up to approximately thirty parts per million. There was a substantial increase from eight to sixteen parts of sulfate. A larger container or smaller number of plants might have indicated even lower results. Concentration needed in the soil solution for optimum growth is indicated to be at least as high as suggested, in the case of special studies made of sulfate and calcium in soil solutions.

Studies With Sulfur for Improving Permeability of Alkali Soil, Joseph D. Haynes, Soil Science 25:443-446.

Alkali soil from Vale experiment field and acid clay sub-soil from the white land or Dayton silty clay loam were placed in series of four gallon jars and treated with various neutralizing reagents to test their value as flocculants or neutralizers and the increase in permeability. Sulfur was especially effective in maintaining a favorable rate of percolation from alkali soil and in producing a more nearly neutral reaction. Lime, manure, and gypsum aided permeability during leaching of acid soil. Alternate wetting and drying increased the permeability by decreasing the effective colloidal fraction of the soil. Sulfur neutralizes soil and increases the reactive calcium, causing an exchange of calcium for sodium on the ultra-clay particles of the soil. Flocculation occurs before neutralization of all the alkali, as does base exchange. In reclaiming black alkali land it is necessary to convert the deflocculated sodium clay to calcium clay, which latter is readily flocculated.

Lysimeter Studies, W. M. Higby, Soil Science 24:51-56, 1927.

Studies were made of the gains and losses in plant nutrients in rainfall and drainage from soil bins four feet deep and about one yard square. From 45 to 77 percent of the 42-inch rainfall percolated through soil bins. More drainage occurred where lime and manure applications were made. The rate, however, is more uniform. An average of 65 to 70 pounds of calcium is lost an acre a year from untreated tanks. Nitrate losses are 25 to 30 pounds, and lime and manure treatments increase this rate of loss. Sulfate is lost at the rate of 50 pounds and this loss increases with liming. Magnesium and potassium are lost at rates of 23 and 16 pounds respectively. Phosphate loss is about 8 pounds in the plowed surface of an acre and is decreased by lime and manure applications.

The Rate of Availability of Various Forms of Sulfur Fertilizers, Joseph D. Haynes, Soil Science 25:447-453.

Sulfur is coming to be extensively used as a fertilizer for alfalfa and as an aid in reclaiming so-called black alkali land when provided with deep drainage and copious irrigation. To be effective, sulfur must be

converted to sulfate form. Three Eastern Oregon soils were employed in a study for determining the sulfate-supplying power of the different sulfate fertilizers, including black gas sulfur, a new commercial material obtained as a by-product of gas plants; "bac-sul," a sulfur containing sulfur-oxidizing micro-organisms; sand sulfur, a crushed crude lump sulfur; powdered sulfur; and Gasco by-product, the latter from the Portland Gas and Coke Company, Portland, Oregon. The study developed that black gas sulfur and inoculated sulfur became available at approximately the same rate and more rapidly than did the non-inoculated sulfur during the first eight weeks. Sulfur increased the population of micro-organisms in alkaline soil and caused flocculation as neutrality was approached. Correction of alkali varies with the amount or kind of sulfur, type of soil, and amount of carbonates present. For neutral soils, crude powdered sulfur that will pass a forty-mesh sieve has been found to become available on most Oregon soils in amounts required to meet alfalfa needs.

A Study of the Colloidal Fraction of Certain Soils Having Restricted Drainage, W. L. Powers, Soil Science 23:487-491.

A special study has been made of means of improving the permeability of certain heavy soils including laboratory and field trials with these soils and soil colloids isolated from them. Sulfur application was effective in neutralizing and flocculating puddled alkali soil. Titration studies with colloids from four heavy soils, including muck, failed to show an iso-electric point. Titration with acids appears to remove mono or dibasic constituents, while the tri-valent cations remain in the colloid with high acidity. Sulfur has been more economically used to improve heavy alkali land when in combination with manure or gypsum. Shading with native vegetation and encouragement of growth on the alkali land aids neutralization or flocculation and the removal of alkali.

Reaction Profile Studies, R. E. Stephenson.

Presented at Meeting of International Soil Science Congress at Washington, D. C. June, 1927.

Soils which show the most consistent profile development show greater acidity in the surface horizon. The surface soil also contains more replaceable calcium than does the subsoil. There is, however, concentration of colloid in the subsoil horizon.

Several soils show no consistent change in reaction, exchangeable calcium, or lime requirement in the different horizons. This irregularity may be due in part to natural interference which prevents mature profile development.

Replaceable Bases in Some Oregon Soils, R. E. Stephenson, Soil Science 24:57-64.

Soils of humid sections are likely to be low in exchangeable calcium, due to the exchange of hydrogen for calcium and the leaching of the calcium. Soils of heavy texture usually show greater exchange capacity, but not always a larger amount of exchangeable bases.

In neutral soils the relative supply of exchangeable calcium is high, which is a characteristic of good soils. In alkali soils the calcium is replaced by sodium. Both acidity and alkali development can be controlled or retarded by proper soil management.

Soil Acidity and Crop Response to Lime, R. E. Stephenson.

Presented at the meeting of the Western Society of Soil Science, at Riverside, California, June 11-12, 1928, and at Conference of Western Agronomists at Berkeley, June 20-21, 1928.

Acid soils are especially likely to be deficient in certain elements of plant food. Very acid soils are usually low in available calcium. Certain anions, the sulfate and the nitrate ion are likely to be deficient also in acid soils. Plants demand both cations, which are acid neutralizers, and anions, which are functionally acid. In acid soils conditions are unfavorable to supply adequately either class of ions. Correction of acidity increases the available supply of calcium and may also increase the available supply of sulfate and nitrate.

The Relation of the Concentration of Calcium Ion Required by Alfalfa to the Amount Present in Soil Solutions, Harold W. E. Larson, Soil Science 25:399-408.

Study of concentration of calcium ion in field and in controlled conditions indicates that at least 16 parts per million is desirable for good growth, and that 32 parts per million is profitable for the most economic growth of alfalfa. Certain soils were found to have a comparatively low concentration of calcium ion, for the best alfalfa growth. At certain seasons, especially in the early part of the growing season, which is the time when the plant requires calcium in large amounts, ground limestone and sulfur applications increase the water-soluble calcium on soils investigated. The exchangeable calcium on the ultra-clay complex varies during the season. It is probable that calcium tends to conserve the base-absorbing capacity of the soil against deterioration. It is probable that ground limestone on certain soils will prove beneficial from a nutritional standpoint as well as from its physical, chemical, and biological effects.

Relation of Soil Fertility to Water Requirement of Plants, W. L. Powers, Jour. Amer. Sec. Agron. 19:1007-1011, 1927.

Sulfur and other fertilizers supplied to alfalfa decrease the water requirement and increase the profit from irrigation farming. Sulfur and sulfates increased the yield on an arid soil from one to two tons per acre and decreased water requirements about 20 percent. Rotation, manure, and supplemental irrigation at the Home Station have been found to double the profit and the returns per unit water and cut in half the water cost per pound of crop as a fourteen-year average.

The Soil Solution as a Nutrient Medium for Plants, W. L. Powers, Jour. Amer. Soc. Agron. 19:1012-1015.

The first percolate from lysimeter tanks filled with the Willamette silt loam at the Oregon Agricultural Experiment Station has been found

to be similar in composition to the displaced soil solution, when the soil is gradually moistened by rains so that channeling or dilution of the percolate with rain water does not occur. The drainage waters from lysimeters, being similar to displaced soil solutions, were obtained in quantity and employed in culture experiments being used (1) unchanged; (2) reinforced with salt solution supplying one or more essential nutrients and compared with lysimeter water; (3) renewed each three days and with so-called complete synthetic solution. When reenforced with salt solution supplying only one essential ion such as nitrate or phosphate little increase in growth of seedlings was obtained. When reenforced with salt solutions containing two or more essential ions, very meager results were obtained for certain combinations. Potassium nitrate added to the drainage water employed produced a growth nearly equal to the growth from a complete artificial culture solution. Potassium and nitrate are both taken in quantities by the young seedlings. Both are mono valent and move at a similar rate through still solution. Calcium enters the plant root very well in association with sulfate, while phosphate may be supplied as phosphate of magnesium, being taken in relatively small amounts by young plants. Full returns may not be obtained for potassium fertilizers on peat soils unless conditions are favorable for the formation of nitrate to accompany potassium into the plant root.

Origin of Alkali Soils, W. L. Powers, Science News Service 1927.

Salty dust storms have been observed to make contributions in the alkali sections of the Northwest to the surface deposit on the lee shores or the northeast edges of playas. Conditions favorable for giving rise to alkali accumulations seem to include (1) an arid climate favorable for high evaporation, (2) compact subsoil or impervious strata and impeded drainage, (3) intermittent saturation with salty solution, (4) accumulation by wind and water.

Studies of Sulfur in Relation to the Soil Solution, W. L. Powers, University of California Press and Cambridge University Press 1927.

In a chemical study of the effects of sulfur and sulfates under controlled and field conditions using typical Oregon and California soils, evidence was obtained of base exchange after sulfur oxidation increased the concentration of the hydrogen ion and then of other cations. The most marked increase was noted in calcium ion- concentration in soil solution and a definite increase in other bases, especially potassium. Calcium and sulfate ions were found to go into the alfalfa plant root especially well together. Heavy applications of sulfur resulted in increased acidity. Sulfur increased the content of plant chlorophyl, improved the reaction of arid soils for plant nutrition, and the sulfate and general nutrient content of the soil solution for such conditions. It is concluded that some soils may have an unfavorably low sulfate content for the best growth of alfalfa, especially early in the growth period; that sulfur may increase calcium concentration and improve the reactions of arid soils. The effect from sulfur application will depend on soil at hand. Ordinary application of sulfur to alfalfa on the arid soils liberally supplied with calcium combinations is probably good practice, especially where growth obtained is consumed on the farm.

Effects of Sulfur and Sulfates in Alkali Land Reclamation, W. L. Powers, First International Congress of Soil Science Proceedings. (In press.)

In a progress report of alkali land reclamation investigations centered at Vale, Oregon, it was shown that applications of sulfur (1) improved reaction and permeability, and (2) aided in removal of alkalinity and salinity and in the establishment of cultivated crops. Sulfur seems to oxidize to sulfate, causing an increase in acidity or hydrogen-ion concentration followed by an increase in calcium, and other multi-valent cations cause release of troublesome sodium from the clay fraction of the soil and flocculation so that leaching can proceed. Growth and decay of organic matter and acids formed by this growth aid flocculation and lessen injury from alkali. Legume green manure such as sweet clover or any nitrogenous organic matter incorporation in the surface soil is helpful. Deep plowing should be avoided and any organic material present or applied should be kept at or near the surface. Getting native greasewood (*Atriplex huttallii* S. Watts) land into pasture by the use of copious irrigation following deep drainage has been especially promising of economic returns. Several valuable pasture grasses and legumes of high alkali resistance, including slender meadow-grass (*Pucenillia nutallia*), *Lennonei* alkali grass, strawberry clover (*Trifolium fragiferum* L.), and Ladino clover or Italian white clover (*Trifoglio bianche lodigiano*), have been introduced and are promising as forage plants.

Nature, Improvement, and Irrigation Requirement of Wild Meadow and Tule Lands, W. L. Powers, First International Soil Congress Proceedings. (In press.)

A description of the profile of typical peat soils in the Klamath basin is presented together with a summary of studies on the reclamation removal of native vegetation, irrigation requirement, and methods of cropping, fertilization, and utilization of these lands.

Factors Affecting Feasibility of Reclamation Projects, W. L. Powers, Modern Irrigation, Sept. 1926.

The Oregon Agricultural Experiment Station has helped develop methods and recognize factors to be considered in soil, agricultural engineering, and economic feasibility surveys of reclamation projects. A large amount of time has been given to investigations in cooperation with the Division of Agricultural Engineering of the United States Department of Agriculture and the United States Reclamation Service. Methods evolved and factors affecting the feasibility of reclamation projects are outlined and briefly discussed.

RESULTS OF INVESTIGATIONS UNDER WAY

PROGRESS and results of the main investigations under way are indicated briefly in the following pages. The reports by departments and branch stations are essentially as prepared by department heads and branch station superintendents. Full credit to staff members is hereby acknowledged.

DEPARTMENT OF ANIMAL HUSBANDRY

The work of the biennium has been along lines followed heretofore, but with some expansion.

A complete study of the goat industry has been undertaken. This will include an economic study of the industry as it exists in the state, a detailed study of the effect of goating upon various Oregon shrubs, and a technical comparison of various types of goat meat with similar types of lamb and mutton. This work is well under way, but no conclusions are yet ready for publication.

Time has been devoted also to electricity on a stock farm, working in cooperation with the department of Agricultural Engineering and the Oregon Committee on the Relation of Electricity to Agriculture. In this work two major objects have been accomplished: (1) the development of a practical feed grinder with an automatic feed and using not to exceed 5 horse-power and (2) the development of a practical electric hay hoist.

The comparative values of whole, coarse ground, and fine ground oats and barley for pigs have been worked out in the form of usable percentages.

At Union a ten-year study of methods of wintering growing steers has been completed showing the influence of winter feed upon the growth, quality, and final cost of the steers from weaning to market. This is the most complete study of its kind on record.

At Hermiston and Union together, seven tests on chopping and grinding alfalfa for fattening lambs have been completed.

Following is a brief statement of work and results by projects.

The cost of horse-power. This project is a matter of long-time continuous record and has been kept up throughout the biennium.

Pasture for pigs. The work with pig pastures has been conducted with a view of getting the yields of pastures through a long series of years. In 1926 one acre of rape replaced 386 pounds of grain. This was a dry year and the rape was poor. In 1927 one acre of rape replaced 2,213 pounds of grain. This was a better year and the rape was unusually good. This test is closely connected with the studies of protein and vitamin deficiencies of barley and tankage. It is still somewhat uncertain as to what extent a saving in grain by pasture is due to the merit of the rape and to what extent to the deficiencies of the check lot. In other words, it is possible that the advantage of the rape would be lessened if it were known how to prepare a more perfect ration for the lots on pasture.

Fineness of grinding grain for pigs. Four tests were conducted during the biennium comparing different methods of preparing grain with feeding the grain whole. Grain ground on a hammer mill with a ¼-inch screen was worth 11.24 percent more than whole grain; grain ground on a hammer mill with a 3/32-inch screen was worth 17.72 percent more than whole grain; steam-rolled grain was worth 17.93 percent more than whole grain; soaking whole grain reduced its value 4.34 percent. In these tests the steam-rolled grain was not prepared in the Station plant. Equipment has since been installed for steam rolling and these tests are being repeated with grain steam-rolled under Station supervision.

Water for pigs. Owing to pressure of other work, no progress was made on this work. It will, however, be continued at the earliest opportunity.

Methods of growing pigs. Particular attention has been given to the use of oats for growing pigs. In four different tests pigs fed oats up to 100 pounds live weight have shown practically the same gain as those fed barley, but when the pigs fed oats during the growing period are put on barley during the fattening period they have in all cases gained more rapidly and more economically than those pigs which had been fed barley during the growing period. The value of oats during the growing period has thus been demonstrated in a practical way. The causes for this difference, however, have not yet been determined.

Protein and vitamin deficiencies of barley and tankage for pigs. The addition of rape pasture to barley and tankage has regularly increased the gains by an amount larger than can be accounted for by the nutrients in the rape. For pigs not on pasture, the addition of alfalfa meal to the barley and tankage ration has consistently increased the gains, and in some cases has lessened the percentage of rickets and other bone troubles. The substitution of oil meal for a part of the tankage has so far given negative results both with and without alfalfa meal. Cod-liver oil added to a ration of barley, tankage, oil meal, and alfalfa meal has given negative results. So far, we have found no supplement to barley and tankage that would produce gains as large as are obtained on barley, tankage, and rape pasture.

Raising spring lambs. The results of this work are now in manuscript form and are ready for publication.

General pasture yields. The records of the yields of all pastures have been continued during the past biennium. A summary of this work follows:

Pasture	Number of sheep days per acre Trials	Lowest	Highest	Average
Permanent pastures				
Native sod, on rolling hills relatively free of brush, timber, and moss	4	311	407	349
Native sod, on rolling hills having considerable brush and moss	10	180	272	226
Sown sod, English rye-grass, orchard-grass, timothy, redtop, and clover	1	.....	.....	786
Sown sod, English rye-grass (first and second season)	2	187	408	333
Sown sod, English rye-grass (first and second season)	1	.....	.....	1256
Volunteer grass in previously cultivated fields	7	187	272	228
Annual or cultivated pastures				
Rape in rows	2	394	1236	815
Clover	6	359	1024	661
Irrigated pastures				
Grass mixtures	4	1517	1841	1673
Winter or spring grazing of hay crops				
Clover and rye-grass hay, early spring grazing	4	40	149	99
Vetch hay, early spring grazing	4	126	253	219
Stubble pasture				
Clover-hay stubble	8	47	319	144
Vetch-and-oat stubble	2	42	61	52
Barley stubble	1	.....	.....	88

Rotation pastures. Rotation of drilled rape, rape and clover, and clover has been carried through four years. The average results follow: An acre of drilled rape has produced 182 sheep days grazing and at the same time replaced 493 pounds of grain as pig pasture. Rape and clover has yielded 283 sheep days of pasture, practically dry weather pasture. Clover has yielded 1.4 tons of hay and at the same time 343 sheep days of pasture. The extreme variability of yields indicates that much is yet to be learned about cultural methods for both rape and clover.

Spring grazing of vetch. This work has been continued with a view to getting a long time average. In 1926, grazing Hungarian vetch to the extent of 129 sheep days per acre between the dates of March 12 to 19 produced a slightly increased yield. Another lot grazed to the extent of 259 sheep days per acre between March 12 and April 20 showed a reduction in yield more than offsetting the value of the pasture. In 1927, grazing even to the extent of 172 sheep days per acre and as late as May 8 did not reduce the yield; in fact, the lot receiving the heaviest grazing actually harvested more hay than the lot not grazed at all. This may, however, have been due to the fact that the vetch on the ungrazed lot was badly lodged and it was impossible to do a good job of harvesting.

Irrigated pastures. Four irrigated pasture lots gave an average yield of 1,033 sheep days per acre in 1926, and 1,678 sheep days per acre in 1927. The pasture is improving each year and the yields for 1928 promise to be distinctly larger than in any previous year. The experiment now gives promise of being an economic success, which was not the case the first year.

Angora goat enterprise study. Farm records have been taken on 37 goat farms in Benton, Lincoln, Polk, and Douglas counties. This work will be continued into the next biennium before any results are announced.

Chevon studies. The chevon studies were somewhat delayed by difficulty in purchasing goats, and also by the slowness of the goats to fatten. A number of goats and lambs, however, have been slaughtered and tested for quality and palatability according to methods perfected by the United States Committee on Quality and Palatability of Meats. We have perfected our technique and the work is now proceeding rapidly.

Clearing brush land with goats. On the slashed area new sprouts continue to grow even though this experiment has been going for four years. There is, however, a very marked reduction in the amount of new sprouts. For the coming year it is planned to goat this area continuously with a small number of goats.

In the unslashed area, there has been a marked thinning of the stand of brush. Seedlings seem to be affected to a marked degree by the browsing of the goat.

Fir seedlings seem entirely killed. On the other hand, on the Scotch Broom area the most intensive browsing possible has failed to kill more than an occasional plant. Efforts to kill Scotch Broom with goats have therefore been abandoned.

Foot rot in goats. In trials comparing the efficiency of copper sulfate, formaldehyde, butter of antimony, and gasoline in treating foot rot in goats it was found that copper sulfate and formaldehyde were quite effective and that gasoline and butter of antimony were quite ineffective. In recent trials it has been found that a mixture of 1 part of copper sulfate, 2 parts of lysol, and 2 parts of vaseline is exceedingly effective in the treatment of foot rot in goats.

Water consumption of sheep and goats. Water consumption for lambs 8 to 10 months of age was 2.5 pounds per head or 2.96 pounds per 100 pounds live weight on a submaintenance ration, and 5.3 pounds per head or 4.26 pounds per 100 pounds live weight on full feed. The water consumption of lambs and kids is approximately the same per 100 pounds of live weight.

Use of electricity. 1. *Hoisting hay.* In the years 1926 and 1927, the entire Animal Husbandry hay crop was elevated with an electrically operated hoist of the double drum type, that is, with one drum for elevating the hay and another for pulling back the fork. This hoist replaced the team formerly used for hoisting and also the boy and horse that is required to pull back the fork in large barns. The work done was excellent in all respects, but it was found desirable to use one man regularly to operate the hoist. Operating from the wagon was only partly successful.

In 1928 a single drum planetary gear hoist made for the Station by the Hesse-Ersted Iron Works of Portland was installed in the horse barn. A single-drum friction hoist of our own design and made by the Hesse-Ersted Iron Works was installed in the beef barn. These single-drum hoists use weights to return the fork, and are operated by one control rope handled by the man on the wagon. This eliminates entirely the use of a special operator. Both of these hoists have been most successful. The use of both horses and driver has been entirely eliminated. It has not proved satisfactory to operate the hoist cables faster than the walking speed of a horse. Nevertheless, a slight saving of time is accomplished through convenience in starting, stopping, and setting the fork. The hoist would make it possible to use a larger fork than any now manufactured, but this would also necessitate a heavier track and carriage. While these hoists are, of course, subject to improvement, the Station is quite ready to give them full endorsement as they stand. A hoist costing $75 and a motor costing $100, replaced in the Station's large barns three horses, one man, and a boy. The cost of power is nominal, and the motor and hoist have other uses.

2. *Elevating grain.* Elevating barley and oats with a blower has not been successful on account of the tendency of the blower to separate the hulls from the kernels. Electrically operated cup elevators have, of course, been entirely successful.

3. *Elevating shavings.* Elevating shavings by means of an electrically operated blower of simple design has been very successful.

4. *Grinding grain.* Grinding grain by means of a small hammer mill with an automatic feed and operated with a 5 horse-power motor has been very successful. Once started, this equipment operates without further

attention. A 5 horse-power motor will grind from 5 to 10 bushels per hour, the rate depending upon the condition of the feed and the fineness of the grinding. Most of the grinding is done at the rate of from 7 to 9 bushels per hour.

Lamb marketing requirements in relation to cost of production. This study is a companion study to the Station investigations of beef marketing, and is intended to show the extent to which the lamb marketing practices may be modified to the mutual benefit of the consumer and the producer. This study deals particularly with Western Oregon lambs and with marketing demands at Portland, Seattle, and San Francisco. A complete study of the marketing demand at Portland is being made and at prices received for different types of lambs checked against the cost of production. A study is also being made of the San Francisco market. This work will be completed during the coming biennium.

Beef marketing requirements in relation to cost of production. This work was completed during the biennium and the result published as Station Bulletin 229, Cattle Marketing Investigations at Portland, Oregon. The recommendations resulting from this work are presented in the review of the bulletin, pages 25-26.

DEPARTMENT OF DAIRY HUSBANDRY

The department of Dairy Husbandry continued cooperation with the Nutrition Chemist in animal nutrition studies and with Veterinary Medicine in studies of diseases of dairy cattle. Much of the time, funds, and effort of the department was given over to these cooperative researches, and results are reported primarily under the other departments. The following is a brief report of the projects undertaken during the biennium.

Investigations in animal nutrition. This was a cooperative investigation with the department of Agricultural Chemistry. It concerned primarily a study of metabolism of dairy cows on rations consisting principally or solely of alfalfa hay. Results are reported under Agricultural Chemistry.

Studies with succulent feeds for dairy cows. *A study of kale as compared with corn silage* for milk production was begun in the fall and winter of 1925-26. A second feeding trial was conducted in 1926-27, and a third in 1927-28. A fourth trial is planned during the fall and winter of 1928-29. The plan of the test is to use 12 cows, divided into two groups of 6 cows each, as nearly equal as possible according to breed, age, stage of lactation stage of gestation, and milk and butter-fat production.

One group was started on corn silage and the other on kale, and after a period of four weeks the feed ration was interchanged, allowing a 7-day interval for the change from one feed to another. After continuing on the interchanged feed for a period of four weeks, each group was changed back to the original ration.

As a general conclusion, results of the three trials indicate that kale in comparison with corn silage would seem to merit a place in the rotation of crops of more Oregon dairy farmers. Cows receiving large amounts of kale did not seem to be able to utilize the increased amount over use made of the kale by cows receiving approximately thirty pounds. Surveys by the Farm Management department indicate that kale is produced at an average cost of approximately $4.00 per ton, with approximately $7.00 per ton for corn silage.

Complete results on feeding trials and conclusions will be reported in publication after one more trial.

Effect of turnips on quality of milk and butter. This study was continued during the first year of the biennium. Results were surprisingly negative. Turnip flavor in milk and butter was not developed by any method of feeding. Decayed turnips and turnips artificially infected with rot failed to produce the turnip flavor. Butter samples stored several months failed to develop off flavors. The general conclusion was that turnips fed after milking, even in excessive amounts, do not produce an objectionable flavor in butter, but may produce an objectionable flavor if fed before milking, especially if the turnips are somewhat rotted. The work will probably have to be repeated, owing to legislation in some states prohibiting the feeding of turnips to milk cows.

Practical studies with alfalfa hay. Feeding trials were begun in 1925 comparing alfalfa hay from Central Oregon with alfalfa grown in the Willamette Valley. These tests have been continued.

In addition, tests have been carried out to compare chopped alfalfa hay with whole alfalfa hay for milk production. Tests have been conducted also to test rations consisting solely of alfalfa hay and alfalfa hay with supplements. The results of these tests will be coordinated with results from metabolism trials and reported in full in the bulletin that is now in preparation.

Mineral requirement of growing heifers. This investigation was continued and three years' data are now available. Twenty-one female animals are in the experiment, consisting of 4 Jerseys, 4 Guernseys, 3 Holsteins, and 10 Ayrshires. The animals have been divided into four groups, 5 in each group, except Group D, which has 6. All animals have been treated the same until about six months of age, except for the fact that they received different roughage, mineral, and vitamin supplements. The calves received whole and skim milk up to approximately the same age and received the same grain mixture. In addition, Group A received alfalfa hay; Group B received at first cheat hay but later oat hay; Group C received cheat and oat hay plus a mineral supplement of steamed bone flour; Group D received a supplement of steamed bone flour and cod-liver oil in addition to oat hay roughage.

Data have been kept on these animals from birth, including feed records, breeding records, growth data, and observations.

A survey of the data showing the weight of the animals and the skeletal growth indicates that there is no great difference in the various

groups in these respects. All animals in the experiment seem to be perfectly normal in growth. The breeding data indicate an abnormal condition in practically all of the animals. To date, this can not be said to be more abnormal in one group than in another. The animals will be continued on experiment through their first lactation period and their second gestation period. It is possible that use of the original animals will then be discontinued and the experiment carried forward with calves dropped by the original animals.

Difficult breeding of heifers. The twenty-one animals in the experiment reported above are giving good data on the problem of difficult breeding in heifers, especially from the nutritional standpoint. In addition, breeding records are kept on all the animals in the dairy herd at the present time, and such information has been tabulated for animals in the herd in the past.

One striking fact apparent is that the problem of difficult breeding does not seem to be correlated with any breed. This would seem to eliminate the male as a major factor. It is noticeable that animals in the regular herd seem to have developed the trouble with breeding to a greater extent in certain years as compared with other years. Whether it is correlated with kind of feed or weather conditions, especially the amount of sunshine, is undetermined. Attempt is being made to collect data as to these factors. Complete records are being kept on all heifers in the herd for comparison with those under mineral study and those under the regular herd management. Approximately thirty-five heifers will be under observation during the coming year.

Data which may have a bearing on this problem are being collected from various breeders throughout the state. The problem is one of real economic importance and is difficult of solution.

Abortion investigations. This project is carried on in cooperation with the department of Veterinary Medicine. The Dairy department has devoted a good deal of time and some funds to the experimental work and especially to the practical application of experimental data in the dairy herd. The Dairy department staff is assuming leadership in putting the results obtained at the Station into trial on dairy farms throughout the state in cooperation with the Veterinary Medicine department.

Sterility of dairy bulls. This project also is in cooperation with the department of Veterinary Medicine. A more complete statement will be given under that department.

Normal growth studies of dairy animals. The collection of data is being continued on this project by weighing and measuring all animals in the dairy herd once each month up to their first calving. The growth curves obtained are used for comparison with the growth of animals under experiment.

Pasture investigations. A good deal of attention has been given to the question of improving pastures in the Willamette Valley. Following the field observations and data collected on various dairy farms during

the first year of the biennium effort was confined during the past year to the question of irrigating pastures in the Willamette Valley. An irrigation system was installed at considerable expense on the new dairy farm and a 14-acre field was seeded to Ladino clover on September 15, 1927. A hay crop was taken from the field in June, 1928, the field has been irrigated, and a fair stand of clover is now ready for pasturing. Complete records as to costs of obtaining the water, development of the irrigation system, preparation of land, seeding, irrigating, and maintenance of the irrigation system have been kept. The field will be used for accurate tests of returns in animal days pasture and milk production compared with other pastures and feeds.

Proved Sire project. (In cooperation with the U. S. Dairy Bureau.) Seven Holstein female calves sired by the bull Colantha Pontiac Hero, No. 277,647, are now in the herd. The idea of this project is to determine whether a bull that has been used on certain blood lines within a breed of cattle and exerting a definite effect, either for good or bad, will show the same effect when used on other blood lines in the same breed.

The seven daughters of the above-mentioned bull will be placed on test when they freshen and their records compared with the records of their dams. Records have been made on the dams of five of these calves during the past year while the other two previously had records.

The second Holstein bull to be used in this project was brought into the herd from Montana in January of the present year. This is the bull Colonel Venus Pieve Paul, No. 331,222. Fifteen animals have been bred to this bull at the presnt time; we should soon, therefore, have further female animals to compare in this project.

DEPARTMENT OF POULTRY HUSBANDRY

The rapid development of poultry keeping as a business has brought demands for more information from the Agricultural Experiment Station. During the past year there has been a general depression in the business, and poultry keepers are interested more than ever in economical production. The Station is being repeatedly called on for information along nutritional lines. Many are anxious to know the comparative value of different feed stuffs and feeding methods. The projects we are now working with are important and valuable. They should be continued. More work should be done on feeding, brooding, and incubation that producers may have facts on which to build and operate their business.

Breeding to extend the profitable age of the domestic fowl. In this experiment the object is to determine whether it is possible to produce a strain of S. C. White Leghorns and a strain of Barred Plymouth Rocks at least 50 percent of the individuals of which can be relied on to lay profitably for four years or more, thus making it unnecessary for poultrymen to reproduce their flocks every year or every two years as is now the case.

The foundation stock selected for this experiment was that which had been bred for high production as reported in Oregon Station Bulletin 180, Egg-Laying Characteristics of the Hen. This stock, though

capable of serving as a satisfactory starting point with respect to numbers of eggs produced, was somewhat deficient with respect to such characters as egg weight, body weight, broodiness, and hatchability. The experiment has now progressed six years, during which time it has been necessary to devote so much effort in attempting to improve these deficient characters that little progress has as yet been possible in additional profitable age. A continuation of the rigid culling and selecting practices employed during this period is causing improvement in these deficient characters.

Indications are that certain factors, such as the use of old or inadequate hatching and brooding equipment, and the breeding problems as stated above, have retarded progress in the experiment. Two years ago new incubators were purchased and last year a new brooder house was built. These improvements, added to those previously made in the physical equipment of the South Poultry Farm, will hereafter make it possible to hatch, brood, rear, and house the stock involved in this experiment in accordance with best known practices, and more rapid progress is expected as a result.

Sufficient experience has been gained to warrant the prediction that disease will constitute the most difficult obstacle in connection with this project. The results in the fifth generation of both breeds were disturbed by an outbreak of chicken-pox. Since then inoculation has been practiced, preventing further trouble from this cause. A serious loss has occurred in the sixth generation of Barred Rocks from paralysis. No satisfactory relief from this cause has yet been devised.

Early laying maturity in relation to good laying, relative influence of sire and dam on offspring, and breed improvement. It is felt that data which must be recorded in connection with the main project, "Breeding to Extend the Profitable Age of the Domestic Fowl," may also be used in solving these problems. These data have been accumulated during the past two years but no tabulations have been made of them for the above projects.

Electric lights for increasing egg production. Investigations on this and the following subjects were undertaken in cooperation with the Oregon Committee on Relation of Electricity to Agriculture. Investigation was conducted to determine full-year returns from lighted and unlighted pens of pullets and hens. When artificial lights were applied to a flock in the fall the response in egg production was almost immediate and the lighted pens maintained the lead over the unlighted pens until spring. At this time the unlighted pens gave sufficiently greater production so that in spite of the lower price for eggs they materially decreased the lead in profits of the lighted birds. Lighting did not increase the mortality. Increased production from lights was not entirely a question of increased feeding period. The birds in the best condition gave the best results from lighting. Increased production was invariably accompanied by increased feed consumption, whether the birds were lighted or not. Lighting is a profitable investment. Station Bulletin 231, Electric Lights for Increasing Egg Production, April, 1928, gives a full account of this experiment.

Brooding with electricity. Chicks may be brooded successfully with electricity where a dependable supply of electricity is available. In normal brooding seasons the cost and results are quite comparable to stove brooding. Power interruptions are perhaps the greatest drawback to electric brooding. In an unusually cold or rainy brooding season electric brooders did not produce as low mortality or quite the quality of chicks as stove brooders. Electric brooding in normal seasons saves labor, is economical, and produces good quality chicks.

Electric water heaters. Electric heating of drinking water for laying hens is practical and worth while. During freezing weather pullets drank 25.4 percent more warmed water than cold water. Drinking water may be conveniently warmed with a number of types of simple electric heaters at a relatively low cost.

Green feed cutting. A motor for a green feed cutter is decidedly worth while. It is a labor saver, helps to maintain an adequate green feed supply, and is economical to operate. During the past two years considerable data have been collected on power cost and labor. As a result of this experiment a number of poultrymen have installed motors. This not only has resulted in reducing the labor cost, but has insured a more constant supply of green feed.

Feed grinding. Considerable work has been done during the past year in grinding poultry feeds with different types of electrically driven mills. As a result of this work a new type of small hammer mill has been designed which will allow poultry keepers to grind and prepare feed more economically than in the past.

Miscellaneous. The established policy of the Poultry department of distributing hatching eggs and pedigreed males to the residents of the state at a nominal price has been continued. It is felt that this policy has aided materially in improving the production of the flocks of the state.

The Poultry department, acting for the Agricultural Experiment Station, has cooperated during the past year with the Oregon Accredited Hatchery and Breeders' Cooperative by supervising the inspection work of that organization. The object of the organization is to improve the quality of eggs, chicks, and breeding stock sold in Oregon.

Twenty lectures have been broadcast from the College radio station KOAC during the year, the subject-matter for the lectures having been taken in a large measure from the Station experimental data.

An educational exhibit was prepared by the department for the State Fair, showing results of experiments and recommendations of the Poultry department.

DEPARTMENT OF VETERINARY MEDICINE

The department has made satisfactory progress during the biennium. The new quarters in the Poultry Building have provided the necessary room for the increased amount of work, which was provided for through increased appropriations by the 1927 legislature.

The experimental production of immunity against avian coccidiosis, the discovery of a satisfactory method of immunizing poultry against chicken-pox, and the success of field experiments in the control and eradication of infectious abortion are outstanding accomplishments.

INFECTIOUS ABORTIONS CAUSED BY *B. ABORTUS* (BANG)

Methods of spread. Since the last report additional data concerning the bull as a factor in the spread of this disease have been obtained. One bull which consistently reacted to the agglutination test was mated with negative females with no spread of the disease. Negative reacting bulls mated with reacting cows continue to fail to spread the trouble when later bred to negative cows and heifers.

Establishment of abortion-free herds from abortion-infected herds. This phase of the work has been expanded very greatly. Based on the knowledge that the disease is not inherited, healthy offspring have been raised to replace abortion-infected dams. Cooperative experiments are under way in fifteen counties with good results in nearly every herd.

Disinfection of barns which have housed abortion-infected animals. Field experiments in removing infected animals from barns, cleaning and disinfecting these barns, and then placing abortion-free cattle in them have proved that this is a practicable procedure. The spread of abortion has been prevented by such disinfection.

STERILITY IN BULLS

As previously reported, there is a close correlation between the breeding ability of a bull and the microscopic appearance of his semen. Further studies have shown that the microscopic findings with seminal specimens from the same bull sometimes vary greatly, even though the two specimens be collected on the same day. Thus a bull may be sterile at one mating and fertile at the next. A single microscopic examination, therefore, indicates only the condition existing at the time of such examination. Several bulls which have been under observation have changed from sterile to fertile for no apparent reason.

Studies of the genital organs of bulls collected on the slaughter house floor revealed that adhesions between the testes and the scrotum are of quite frequent occurrence and are of no pathognomic significance. A series of microscopic slides of semen from more than 200 bulls failed to reveal any tailless spermatazoa such as have been described by some authors as being commonly found in abnormal semen. Such tailless sperm cells have been produced by manipulation of semen after it was placed on a glass slide. These studies indicate that such abnormalities in spermatazoa are not as frequent as some reports state that they are.

PARASITIC DISEASES OF SHEEP AND GOATS

Liver flukes.

Eggs—hatching experiments. Eggs collected and kept in water at room temperature began hatching in 21 days and continued to hatch for 120

days. Freezing for 24 hours at 8° F. did not prevent the hatching of eggs which had not embryonated. Embryonated eggs failed to hatch after such freezing.

Miracidia. No miracidia were ever observed to live longer than eight hours after emerging from the egg. The juices of several species of fresh-water snails failed to attract miracidia. Freshly hatched miracidia were placed in water containing several different species of fresh-water snails, but in no instance was there evidence that they penetrated any snail.

Possible snail hosts. Six different species of the snail genus *Lymnaea* have been collected in Oregon. One of these has been identified as *L. truncatula,* the same species which acts as the secondary host for the liver fluke in Europe. *Lymnaea* very similar to, if not identical, with *truncatula* have been collected in the vicinity of Corvallis from February 3 to November 29.

Three different cercaria (immature flukes) have been observed in these snails. One of these is very similar to the cercaria of the liver fluke. Of the other two, one is forked-tailed and one is larger than the liver fluke cercaria.

In addition to the *Lymnaea* ten other species of fresh-water snails and four species of land snails have been collected and examined for cercaria. Six cercaria, none of which very closely resembled the liver fluke form, have been found in these snails.

Immature flukes. Autopsy examinations have revealed immature flukes as early as July and as late as February. They have been found in very large numbers in July, August, and September. Medication with carbon tetrachloride has not resulted in the destruction of these immature forms.

Mature flukes. Autopsy examinations have revealed mature flukes from July until March. Thus, fluke eggs are expelled for at least nine months of the year.

Symptoms of fluke infestation. Two distinct sets of symptoms have been observed, one caused by the immature fluke before it reaches the bile ducts, and the other by the mature flukes in the bile ducts and gall bladder.

Immature flukes may cause symptoms and death as early as July. Mature flukes usually cause symptoms and death during the late fall and winter months.

Lung worms.

Larvae. Lung-worm larvae were not destroyed by freezing for five days, thawing, and freezing for five days more.

Mature worms. Many different vermicides have been tried as intratracheal injections, but no satisfactory treatment has been found.

Stomach worms.

Genera affecting sheep and goats of Oregon. Hemonchus contortus, the common stomach worm, has not been found in Oregon. *Ostertagia, Tricho-*

strongylus, and *Nematodirus* are present in nearly every sheep or goat in Western Oregon.

Season of the year when infestation occurs. Mature *Ostertagia* were found in a six-weeks-old Willamette Valley lamb autopsied March 3, 1928. This indicates that stomach worms may be picked up in winter as well as in summer.

Treatment. Copper sulfate has not proved satisfactory in field experiments. Tetrachlorethylene has apparently given good results in field trials.

SALMON POISONING IN DOGS

Further studies of this problem have shown that the fresh-water snail, *Goniobasis plicifera* var. *silicula* (Gould), is the molluscan host of the fluke *Nanophyetus salmincola* Chapin-Hall, which causes salmon poisoning. Four cercaria have been found in these snails. Studies have indicated that the one of these which occurs most frequently is the immature salmon poisoning fluke. Attempts at producing immunity against salmon poisoning have failed.

POULTRY DISEASES

Coccidiosis of poultry. Experiments have proved: (1) small doses of coccidia do not necessarily produce symptoms in susceptible birds, (2) repeated small doses produce a very high resistance, (3) such resistance can be regularly produced through the regular administration of sublethal doses of coccidia.

It has been shown that there is a strain of coccidia which attacks the caeca only, and another strain which attacks the small intestine only. Immunity against one strain does not necessarily protect against the other.

White diarrhea of poultry. Data accumulated have continued to indicate that the agglutination test is a satisfactory method of diagnosis.

Chicken-pox. A method of vaccinating young fowls against chicken-pox has been worked out. Vaccination is in the skin, and not subcutaneous. Non-attenuated virus is used. Immunity is produced in four weeks or less. This immunity has lasted at least two years in some fowls. Approximately 60,000 birds have been vaccinated by this method.

Blackhead in poultry. Experiments have been started with ligation of the caeca as a possible means of prevention of blackhead.

DEPARTMENT OF FARM CROPS

Farm crops in Oregon are becoming increasingly important. In 1927 the annual value of such crops was substantially more than 70 million dollars. The results of experimental work at the Corvallis and

Branch Stations accounts for a substantial increase in the percentage of returns in yields and in cash values to farmers of the state.

The following report is a brief statement of work and results by projects during the biennium.

CEREAL AND FLAX WORK

Winter wheat. Varietal trials show White Winter and Queen Wilhelmina or "Holland" (true winter varieties), and Jenkin and Rink (spring varieties), to be best for Western Oregon.

Jenkin is best for warm soils. Two selections of Jenkin, Oregon 158 and 160, look promising.

Spring wheat. Huston, Marquis, and Zimmerman are the highest yielding spring varieties. Zimmerman was recommended for the first time in 1928. It is a white spring wheat. To meet market and growing conditions for some soils, there is still need for better white spring wheats.

Spring oats. Oats occupy approximately 35 percent more acreage than wheat. Much improvement in production of oats will follow the adoption of the Agricultural Experiment Station recommendations. Victory is the highest yielding spring variety and Gray Winter is the best fall variety. Other good varieties for spring sowing include Three Grain and Golden Rain. More work is especially needed with winter oats for Western Oregon.

Barley. Barley varietal trials have been enlarged. OAC No. 7 continues the highest yielding variety for fall sowing. Hannchen, the highest yielding spring barley, and OAC No. 7 are both good spring varieties. Trebi and Peruvian show promise. Withycombe, a hooded variety from the Union Station, appears promising.

Fiber flax. Fiber flax work is carried out with rather intermittent cooperation of the Fiber Office of the Bureau of Plant Industry. Saginaw is probably the best of the commercial varieties. J. W. S. and several selections from Saginaw furnished by the Office of Fiber Investigations appear very promising.

Cultural experiments show better production and length of fiber flax sowed with a drill than with broadcasting, and on firm rather than loose seed-beds. The 95-pound rate of sowing is proving better than the commonly accepted 110- to 115-pound rate. Early planting gives significantly better results than later planting.

The major cultural operations are pretty well standardized but experimental work should be undertaken to improve varieties and to develop better harvest, retting and scutching methods. There should be additional investigation of suitability of varieties to the various soil types.

Seed flax. Damont and Linota have been the highest yielders. Early sowing with a grain drill on a firm seed-bed gives best results. More investigation is needed on seed treatment to control a wilt-like disease attacking Damont. An adequate seed supply of these varieties is much to be desired.

TILLAGE TRIALS

Tillage trials begun in 1921-22, are being concluded, because of loss of land, with the crop of 1928. These trials include time and depth of plowing, method of seed-bed preparation, and rate and date of seeding, for both winter and spring wheat. It was originally planned to use a rotation of cereal and clover but failure of clover stands on the rather poorly drained soils made necessary the more general use of a rotation consisting of cereal followed by vetch.

Plowing. Land plowed before fall rain gave slightly lower yields than that plowed afterward. Disking of these lands before fall plowing had little effect on yield. Plowing 8 inches deep gave a yield increase over a 5-inch plowing, but little increase was obtained over 8-inch plowing by plowing 11 inches deep for fall grain.

With spring plowing for spring grain, disking previous to plowing helped the yields of late-plowed plots. Without disking previous to plowing the lowest yields were obtained from the shallowest plowing. For late plowing the depth made little difference. Early-plowed plots produced better than late-plowed ones. Winter wheat yielded more than double that of spring wheat on adjacent plots.

Seeding. Fall sowing of winter wheat about mid October, using 8 pecks per acre, gave best results. Early spring sowing of spring wheat at 6 pecks per acre appears best and most economical.

New land must be obtained for the proper working out of an adequate tillage trial, which should be on a sufficient acreage to carry it out in a recognized crop rotation.

CEREAL BREEDING AND CORN WORK

Nursery. The nursery includes 3,000 to 3,600 rod rows and approximately 2,000 head rows and numerous individual plants. The work is sufficiently valuable that the Cereal Office is considering bringing a good deal of its work to Corvallis.

Wheat breeding work. Selections from the field and hybrids developed here and at other stations are being grown to obtain a hardier type of Jenkin for fall sowing, a higher yielding type of wheat for fall and spring sowing, and a white spring wheat for Western Oregon, and to obtain greater freedom from the diseases commonly affecting the crop. Work is being done to obtain resistance to rust, smut, and foot rot.

Oats. Promising hardier strains of Gray Winter oats are being increased. Madrid, a spring variety of yellow oats, has been introduced and shows promise.

Barley. Hardy selections of barley are being worked upon with the idea of increasing the safety in producing that crop and extending its area into higher altitudes and into the northern part of the Willamette Valley. The Withycombe hooded spring barley has been found superior to the other hooded barleys now grown.

Fiber flax selections. Numerous selections of fiber flax were made in the fields near Salem and from some of the plots at Corvallis. These are being grown to determine superior fiber quality and freedom from disease, particularly rust.

Potato breeding trials. Potato breeding trials are being carried out in a limited way.

Nursery land needed. For breeding purposes, and particularly if a cooperative agreement is reached with the Cereal Office, the Station should have twenty acres of mellow, well-drained land, free from overflow, in a suitable crop rotation, in order that the nursery work may be properly carried out.

Corn. Corn variety trials demonstrate that a general purpose corn is not suited to the needs of the state. Silage users demand a larger tonnage than do the grain growers, who stress maturity. Minnesota 13 is a satisfactory early-maturing variety, while McKay Yellow Dent is a superior silage variety.

Interesting results have been obtained in the use of fertilizers and seed treatments in the hill with seed corn. Land-plaster in the hill with seed corn has improved yields, particularly of forage, in a substantial manner. It has been superior to the organic mercury dusts on the market. Readily soluble fertilizers placed in the hills with the seed have injured the stand.

FORAGE

This project is a cooperative one with the Bureau of Plant Industry, and is the largest project of the department from the standpoint of State and Federal funds invested.

Legumes. These important crops have been a major subject of investigation and continue in that status. The demand for them in Western Oregon is acute. They are needed on more of the farms and in larger acreage and with greater frequency in the cropping systems if profitable yields of forage and proper soil fertility are to be maintained.

Vetches. The Station expects to be able to distribute in the immediate future a selection of *Hairy vetch* less inclined to shatter than the types commonly grown.

Two early maturing types of Common vetch, No. 13430 and No. 16462, show promise as green manure crops in California. Both are early maturing types. Noena vetch is showing promise on the Coast.

Monantha vetch, which has been experimented with for many years, is now beginning to find a place in the seed market. According to a study in the Southeastern States by a member of the Station staff in 1928, this vetch is suited particularly to the southern part of the Southern States, but is probably not hardy enough to find a consistent market north of the middle of Georgia and Alabama. It is an excellent seed producer and is sufficiently hardy to withstand a good many of the weather conditions on well drained land in the Willamette Valley.

Hungarian vetch, introduced by the Station some years ago, is now generally distributed in the Willamette Valley and has superseded other vetches to a considerable extent. The vetch acreage is estimated to be approximately 80 percent Hungarian for 1928.

Hairy vetch continues to be grown on a moderate scale as a seed crop for sale in the Southeastern States.

Austrian winter field peas are also much in demand in the Southeastern States in those areas where winter hardiness is necessary. They are well suited to many of the medium heavy soils in the Willamette Valley.

Experiments to date show that they do best on a well prepared seed-bed and are not well suited to stubbling in. Their hazardous points are (1) approximately as susceptible to aphids as Common vetch; and (2) are attacked by pea weevil, hence prompt threshing and immediate fumigation after threshing are necessary to put the crop on the market in good condition.

This seems the most outstanding of the new facts in legume experimentation in recent years.

Alfalfa. The acreage in alfalfa is increasing rapidly and excellent satisfaction is being obtained with it. Varieties in the variegated group continue to show best, with Grimm the most outstanding of these varieties commercially available. Strain trials of Grimm from different states show little difference. Grimm and related varieties appear resistant to stem rot, which probably accounts for their popularity in our mild climate.

Rate- and method-of-seeding trials of alfalfa indicate that good stands may be had with small quantities of seed. It appears that favorable conditions for growth, such as a good seed-bed, successful inoculation, and good moisture and plant food conditions, have more to do with obtaining a good stand than small variations in the amount of seed.

Good, thick, vigorous stands seem necessary for continued production of high yields.

Red clover. The strain trials of Red clover are being continued. *Chilean* strains are high forage producers. *Italian* strains are low. *Local Oregon* strains are very satisfactory.

The Tennessee anthracnose-resistant variety seems well suited to our conditions as a seed crop. If seed produced in Oregon maintains its dis-

ease-resistant qualities when returned to the disease-infected area there is a possibility for a large industry in the production of this crop. Various lots of Oregon Red clover seed are being tried out in eastern experiment stations to locate hardy strains suited to the north central states' conditions. When varieties suited to their conditions are selected, they can be standardized upon in Oregon production. Varieties or strains which have proved satisfactory will command premiums instead of the present tendency to take discounts.

In the seeding trials with Red clover the most generally economical method is that of sowing the Red clover in the late winter on fall grain. The two methods most likely to produce stands are this one and sowing alone on a well prepared seed-bed later in the spring. This latter method is recommended mainly where lands are weedy, or on run-down lands where stands are difficult to obtain.

Soy-bean. Soy-bean work is being continued with the thought that soy-beans may supply an annual leguminous forage and rotation crop suited to planting after it is too late for vetches. *Dunfield* and *Wea* are two promising new varieties.

Zigzag clover. A special effort is being made to make selections and to develop methods that will bring this perennial clover into commercial seed production.

Sweet clover. A sweet clover resistant to stem rot is being developed. This is important as that disease is a limiting factor in Western Oregon.

Strawberry clover. While not a success as compared with other clovers in this area, Strawberry clover is being observed and studied in some of the alkali sections where its production indicates it to be an excellent alkali pasture clover and to have turf-forming possibilities on alkali soils that may be kept well watered.

Grasses. Numerous nursery, plot, and field trials are being carried out with grasses to determine their suitability to conditions, their forage value, and seed production possibilities and methods. Among these, the outstanding forage grasses include *English rye-grass, rust resistant timothy, meadow-foxtail, Kentucky blue-grass, orchard-grass, tall oat-grass,* and *red-top.* Among the grasses that are less common but that show possibilities for forage and seed are *Reed canary-grass, tall fescue, Chewings fescue,* and a strain of *Harding grass.*

Particularly interesting from the standpoint of *pasture work* is the performance of *Kentucky blue-grass, red-top, meadow-foxtail, English rye-grass, tall oat, timothy,* and *orchard-grass.*

Pasture. Land for conducting proper pasture trials at the Station is not available. Field studies indicate the following:

1. The pasture problem in Western Oregon is probably the biggest agricultural problem.

2. Establishing pasture on logged-off land is a large part of the problem.

3. Economical pasture establishment demands that it be done on a good "first burn."

4. Numerous observations show that good stands may be easily obtained by fall sowing on a good burn.

5. To be permanent and resist encroachment from brush the pasture mixture must include sod formers and the pasture must be kept pastured.

6. Permanent legumes seem important from the standpoint of productiveness, fertility maintenance, and quality of feed. Burr clover, Ladino clover, and common White clover are excellent.

7. Irreparable damage has been done many loggings through losing the long time effects of a first burn by sowing cheap and temporary "burn" mixtures.

8. It appears that rotation grazing which will permit close pasturing is desirable.

9. Unseeded, burned-over land or land seeded to the temporary burn mixtures quickly comes back into brush.

10. The Station's recommended pasture mixture for burns is giving excellent results.

Grass seed production work is being studied with tall oat grass, orchard-grass, meadow-foxtail, timothy, Kentucky blue-grass, and the rye-grasses.

Studies of different bent and other turf-forming grasses are being continued.

Lemmon's Ammonia alkali grass is a promising new Eastern Oregon grass observed in Morrow county. It has forage and turf possibilities.

ROOT CROPS

Root trials show turnips and rutabagas unsuited to Corvallis conditions. The New Zealand White Belgian carrot is the most promising variety of carrots. Mangels are the outstanding root crop for Western Oregon. Half Sugar, Danish Sludstrup, Mammoth Long Red, and Red Intermediate are good varieties. Heavy Cropper and the Barres Styno show much promise. Some work is being carried out with different varieties of sugar beets.

Miscellaneous forage work. A study is being made to determine the best state of maturity for the harvest of various grass and legume crops.

The nursery is a means of proving various introductions suited to more extensive trials and on the other hand eliminates enormous numbers of forage crops unsuited to the conditions.

Among the more outstanding bits of nursery work are trial studies of the White French Jerusalem artichokes; the cold-resistant variety of Bermuda grass, strains of Reed canary-grass, and meadow-foxtail that are rather non-shattering in habit, and strains of different bent grasses and their variations.

Agricultural Experiment Station Circular 85, Green Feed and Pasture for Poultry, has gone to press.

POTATOES

The potato experiment continues to show that the blossom-end method of cutting is superior, and that early planting, approximately five inches deep, of blocky seed pieces coated with land-plaster is the most satisfactory practice for commercial production. Cut potatoes exposed to strong sunlight immediately after cutting are damaged 50 to 60 percent as indicated by stand and yield.

LINN EXPERIMENT FARM WORK

Crops are being grown under irrigation to determine the economy of the application of water. This includes clover for seed and hay, grain and potatoes in rotation. Alfalfa is grown alone in another area. This problem is complicated by a number of plot experiments.

SEED LABORATORY

During the biennium 2,869 samples of seed were received for analysis; of these, 95 were forwarded to the California laboratory during the absence of our analyst for vacation or other reasons.

The Station seed laboratory made a total of 1,198 purity tests, 2,066 germination tests, 66 examinations of samples, and 171 identifications. the work of the seed laboratory is much appreciated and many commendatory statements are received from the seed trade.

WEED CONTROL WORK

At intervals as time permitted some weed control work has been undertaken.

A number of chemicals, including KMG, carbon bisulphide, sodium arsenite in the form of USCo weed killer, and sodium chlorate have been tried.

Station experiments together with observations in the field indicate that carbon bisulfide under the right conditions is a good killer, but that as it is ordinarily applied under a majority of conditions, it is too expensive and is not generally successful. Too much depends on a proper understanding of soil conditions to make it a very safe method to recommend, even if its expense were more moderate.

KMG is so generally unsuccessful that we are unable to recommend it. Sodium arsenite is only fairly successful, although probably more promising than either of the others mentioned. It has given fairly good results on Russian Knap weed, Canada thistles, and wild morning-glories.

The most outstanding weed killer is sodium chlorate. This applied at the rate of one pound sodium chlorate to one gallon of water killed

quack-grass with a single application. It made probably a 95 percent kill on Russian Knap weed in Wasco county with a single application. On wild morning-glories in both Benton and Wasco counties it made kills of 90 and 85 percent respectively. It also made a good kill, probably 80 percent, on Canada thistles in Benton county. More work must be done on strength of solution and time and manner of application. Suggestion of this chemical was gained from a Kansas Station report. It is being tried this year on all the above weeds and on nut grass.

MISCELLANEOUS

Much miscellaneous non-project work is carried on. This involves numerous letters to farmers, county agents, seed companies, government officials, and others. It involves the preparation of material for Fair exhibits, addresses to seed and grain meetings, newspaper articles, radio articles, and miscellaneous meetings. It involves the meeting with and discussing individual problems with numerous dealers, producers and consumers, as well as much other related work.

DEPARTMENT OF SOILS, IRRIGATION AND DRAINAGE

Investigations of this department are conducted under a special biennial state appropriation, amounting to $10,000 a year for soil surveys, drainage, irrigation, and soil fertility investigations. All field and laboratory experiments of the Soils department at Corvallis are maintained on this fund; likewise, about $2,000 a year for half the expense of the cooperative soil survey, in agreement with the United States Bureau of Soils; about $2,500 a year for cooperative irrigation and drainage investigations with the Federal Division of Agricultural Engineering; about $1,000 a year for publications; the alkali land reclamation experiment field at Vale, including the oldest field experiments of this kind in the Northwest; some 24 cooperative field fertilizer experiments with different soil types; and the state experiment station time of staff specialists used in rehabilitation project surveys.

Investigations are correlated by a soils committee including the soil bacteriologist and agricultural chemist.

COOPERATION WITH THE U. S. DEPARTMENT OF AGRICULTURE

Soil surveys. In cooperation with the United States Bureau of Soils a detailed soil survey of the Willamette Valley has been completed during the biennium. This survey was started in 1915 and covers all land in this area outside the National Forest, about 6,000,000 acres. Soil surveys were also completed for the Grande Ronde Valley and for the Ochoco irrigation project. A similar survey of Columbia county was started in 1927 and should be completed by the end of this growing season, 1928, making a total of more than 6⅜ million acres covered by detailed soil surveys.

It would be highly desirable for the Experiment Station to publish a general soil map and report of Willamette Valley soils and their

utilization, combining the county maps on a half-inch scale and including the chemical analyses and results of reclamation, rotation, and fertilizer experiments accumulated.

Official samples of each soil type in each county have been collected and submitted to the department of Agricultural Chemistry for analyses. These analyses have been completed for all Willamette Valley counties and for the Grande Ronde area. From these soil maps and analyses a farmer can be advised as to what type or types of soil cover his farm, and their average composition. The field and greenhouse fertilizer experiments which follow on the main soil types give fundamental information as to the means of soil utilization. These surveys serve as an invoice of agricultural resources; as a basis for soil investigations; are useful in locating experimental fields or highways; aid in introduction of new crops and farm practices, and in establishing permanent systems of soil management.

General surveys have been made of practically all reclamation projects, either at the time of initiation or for purposes of revamping, or rehabilitation. Reports on file in the soils office are public data and may be consulted. The published soil reports are much in demand by landowners, farmers, and prospective settlers.

Reclamation. The Division of Agricultural Engineering of the United States Department of Agriculture has cooperated in making feasibility soil agricultural and economic surveys of reclamation projects, including Ochoco, Warm Springs, Grants Pass, and Tumalo. This cooperation was obtained by the Experiment Station following a request in 1926 from the State Securities Commission to assist in developing plans for the rehabilitation of these projects.

This Division Agricultural Engineering, U. S. Department of Agriculture, has cooperated in a study of economic methods in clearing, fitting, and irrigating soils in Rogue River Valley; a special study in Grande Ronde Valley; and the cooperative work has now been extended to include a special study of the possibilities of drainage in this valley by means of pumping.

In all of this cooperation the Federal department has contributed fully half the cost.

Cooperation with farmers. Excellent cooperation has been obtained from farmers who have made possible a considerable number of cooperative experiments.

Soil fertility investigations. Experiments with fertilizers, lime, and soil building rotations are being maintained coincident with the soil survey, to develop practical means of maintaining profitable production. Field and laboratory experiments are conducted by soil workers with some assistance from graduate students and with the cooperation of the chemist and the bacteriologist of the Station. In addition to maintaining field trials or long-time experiments, fundamental laboratory studies conducted are being reported as special scientific contributions listed elsewhere. A few of the soil fertility and plant nutrition studies on which progress has been made will be cited as illustrations.

Sulfur for alfalfa. The Oregon Agricultural Experiment Station was perhaps the first to discover the value of sulfur as a fertilizer for alfalfa. The treatment is now used on about 40,000 acres of alfalfa in the state. The gain in hay yield is about 40,000 tons annually. The net increase in value is $240,000 or more, with possibilities of about three times this amount, since approximately 120,000 acres of alfalfa in the state will respond to this treatment. The cost is approximately $1.00 per acre per year, the increase obtained being from 1 to 2 tons of hay per acre.

Recent investigations show that some of our soils in the arid sections are improved in calcium and sulfate concentration in the soil solution by sulfur treatment, and that sulfur frequently improves the reaction of arid soils for alfalfa nutrition.

Recent investigations indicate also that sulfur ground to pass a 40-mesh sieve will become available at a rate adequate to meet crop needs, and that on alkali land inoculated sulfur or black gas sulfur acts a little more quickly, while on normal land sufficient sulfur-oxidizing bacteria are usually present. Sulfur used in conjunction with barnyard manure or legume green manure is very effective for improving the reaction and permeability of black alkali land.

Lime. Most of the soils in the humid sections of Oregon are unfavorably acid for best growth of soil-building legume crops, such as red clover. On certain red-hill soils in the foot-hills of the Willamette Valley and on the Coast even legumes more resistant, such as vetch, may fail without liming. This treatment becomes fundamental to establishment of permanent agriculture.

Recent investigations show that some of our soil solutions may be unfavorably low in concentration of calcium for the best nutrition of legume plants. Liming has paid in the 15-year trial on Willamette silt loam at the Home Station, and has improved the physical condition and growth of nodules on legumes to some extent, as well as grain yield in the rotation. Lime has increased the formation of nitrate in the soil.

As a result of a consistent campaign the use of ground limestone is becoming more general and more firmly established. Liming has made possible the elimination of summer-fallow on certain red-hill farms, and the growing of legumes, such as clover, sweet clover, and even alfalfa, thus building up the soil so that the diminishing grain yields can be checked and profitable yields again assured.

Phosphate. Experiments have shown that applications of phosphate fertilizers in combination with manure on "worn-out" grain land in the Willamette Valley will give profitable increases with grain and corn, and that this is a profitable treatment for potatoes on the red-hill soils. Liming and maintenance of organic matter by green manures and barnyard manure aids in maintaining available phosphate in Western Oregon soils and, according to recent studies at this Station, should check losses of this element.

A bulletin is in preparation dealing with uses of phosphate fertilizers on Western Oregon soils.

Crop rotation. Trials of crop rotation and manure with supplemental irrigation have been under way at the Home Station for fourteen years. At first this experiment field yielded 12 bushels of beans per acre. Continuous cropping has reduced the yield below 6 bushels, while rotation, manure, and irrigation have increased the yield to almost 30 bushels per acre. The average fourteen-year yield has been doubled and the water requirement cut in two by rotation with legumes and manuring once each rotation in connection with supplemental irrigation. Maintaining a rich, well balanced soil solution will save about one-third the water commonly used on irrigation projects, and will improve the quality and yield of the crop and conserve the soil.

An experiment with soil-building crop rotations, including ninety plots, has been closed after a period of fifteen years. At the close of this period experimental plots which were continuously cropped to grain were yielding about 24.5 bushels per acre of barley, while the best rotation, including clover and a manure crop in the rotation, yielded 48 bushels per acre. Alternating grain with vetch and corn has given an increase of 14.1 bushels per acre and rotating with clover and a row crop has increased the yield of grain approximately 18.7 bushels per acre.

Barnyard manure. Plot experiments have been maintained seven years to learn the economic rate, time, and method of applying barnyard manure to obtain most economic returns when used alone or in conjunction with other treatments. Better returns are realized where the manure is used in connection with lime or phosphate, provided it is disked and plowed under before seeding. The economic rate of application here seems to be approximately 10 tons per acre. The influence of a 20-ton application was observable for five years.

Legumes, green manure cover crops, and barnyard manure have aided in obtaining deeper penetration of irrigation water on heavy soils in the Rogue River Valley, and have increased the size and yield of fruit. Application of experiment station data through demonstration experiments and fertilizer cover crops has improved the orchard practice in fruit-growing sections.

Potassium. Soil analyses and field fertilizer trials, as well as controlled greenhouse and laboratory tests, show that much of our peat soil is low in potassium and benefited by its application. Potash also pays as a fertilizer for potatoes in the residual soils in Deschutes Valley.

Recent investigations show that full returns may not be expected from potash unless nitrate is present to accompany the potassium into the plant root. In a fertilizer experiment with peat from Lake Labish where the soil's potash content is only one-fifth of that in the normal Valley floor land adjacent to the lake, it was found that potassium sulfate was effective for increasing the soluble potassium, while the greatest yield of mint and length of fiber flax were obtained with potassium nitrate or potassium applied in association with nitrate. Barnyard manure was effective in increasing the potash and nitrate content of the soil solution. The most economic returns appear to be realized by combinations of barnyard manure and potassium sulfate on this soil. The potash nitrate relation was also found to hold in the Deschutes Valley.

Greenhouse and field fertilizer experiments with fiber flax during the past three years show that potassium is a very important nutrient for increasing the length and value of fiber flax. It seems to keep the simple carbohydrates in solution until they can be deposited in the fiber-forming portion of the flax plant. Potassium may also act to stimulate the formation of carbohydrates, or to serve in the formation of so-called organic catalysts or enzymes.

Nitrate. In Western Oregon cool, damp weather inhibits nitrate formation, and in winter seems to facilitate leaching out of available nitrates. A light application of nitrate early in the spring has proved profitable on unfavorably light-colored grain fields and on cover crops in many orchards. Sodium nitrate can be most safely used on soils tending to be acid, while ammonium sulfate is proving more effective on neutral or alkaline soils of heavy texture where continued use of sodium salts tends to cause alkali trouble.

Indirect fertilizers have proved useful for increasing the growth of shade crops and cover crops on run-down orchard soils. These applications may be lessened or discontinued after fertility is restored so that a good growth of legume cover crops and good new terminal growth on the tree occurs.

Drainage investigations. The Willamette Valley soil survey shows that approximately one million acres can be reclaimed or doubled in productiveness by drainage. Fifteen years' study at the Home Station has developed methods for tiling and improvement of leading wet soil types, such as "white land" or Dayton soil series, while the tide-land at the Astoria Branch Station and alkali land at the Vale experiment field has been studied several years.

Drainage surveys of the larger wet areas in the Willamette Valley have been made in cooperation with the U. S. Division of Agricultural Engineering. It has been found that four out of five farms can be tiled without district organization. One-quarter million acres will require district outlet ditches, the average cost of which has been estimated as $10.00 per acre. Every valley county has its drainage problem, yet the larger wet areas are to be reclaimed in the upper valley.

In the state as a whole some 56 drainage districts have been organized and 200,000 acres provided with district outlets. The estimated increase for this area in annual crop value at $5.00 per acre is one million dollars.

In ten years 225 miles of tile systems have been designed along the lines worked out at the Station, largely as Extension work, and these systems have reclaimed nearly 15,000 acres. It is estimated that the crop increase is $10.00 per acre, or $150,000 per year.

Studies have been initiated to determine for certain areas the feasibility of pumping for drainage, and the use of the water in supplemental irrigation. Conditions are promising for success for deep drainage, avoidance of alkali troubles, and the use of the water removed for augmenting irrigation supply in certain regions of Eastern Oregon. These

studies are in cooperation with the United States Division of Agricultural Engineering, and a research specialist has initiated investigations.

A recent Station circular reports methods of draining and improvement of the white lands, and a progress report has been made on the alkali reclamation work centered at Vale, where some successful crops have been established on land formerly of a wet character.

Assistance has been given in feasibility, economic, agricultural, and soil surveys of many drainage projects. Recently much help has been given to the Scappoose drainage district, Wapato Lake project, and the Coquille Valley.

Alkali land reclamation. The alkali problem constitutes one of the most difficult soil problems in the West. The oldest alkali experiment field in the Northwest is located at Vale, where reclamation studies have been centered. Here most of the ideas regarding possible means of improvement of alkali land have been tried out. Hundreds of analyses are made yearly in observing the progress of reclamation. From one-fourth to three-fourths of the alkali salts have been eliminated with various promising treatments employed. Elemental sulfur has been the most effective single treatment for neutralizing alkali and flocculating soil so that leaching could proceed where deep drainage and copious irrigation are provided. Less sulfur is needed when used in conjunction with manure. Getting uncleared greasewood land into pasture mixture with the aid of copious irrigation has been very promising of economic results and has produced pasture of good carrying capacity. Several alkali-resistant grasses and legumes have been established in connection with this experiment field, including slender alkali grass, strawberry and Ladino clover, as well as sweet clover and rye-grasses.

The work on the alkali experiment field needs to be strengthened and additional studies are needed in the reclamation of peat land and their utilization.

Irrigation investigations. Studies on the value of supplemental irrigation in the Willamette Valley have been under way for twenty years. On the Willamette silt loam of the Valley floor potato yields have been increased 56 bushels per acre, hay 2 tons, beets 5 tons, beans 5 bushels, and corn and kale 3 tons. Economic studies indicate that it will pay to pump 25 to 40 feet for crops like alfalfa, and about twice that lift for potatoes.

Factors affecting economic lifts are discussed in a new bulletin dealing with the economic limit of irrigation under Willamette Valley conditions.

The Station has extended studies of the value of supplemental irrigation, with an experimental well and pumping plant serving some 50 acres of river-bottom land a mile east of Corvallis, a project in which several departments are cooperating. Water variation trials and field fertilizer experiments are included in the soil section of this work. It appears that 75 to 100 percent increase can be made with certain crops on the river-bottom as readily as a 50 or 60 percent increase has been made with supplemental irrigation on the Valley floor.

Economic methods of irrigation and of clearing and fitting land have been a subject of study in Southern Oregon for two seasons. A large head applied with the strip-border method has made it possible to apply water in an amount representing approximately the usable water capacity of the coarse granitic of Siskiyou soil in the vicinity of Grants Pass, while near Medford a small head, such as a half-inch stream, run through furrows a quarter of a mile long has been effective in distributing water to orchard land of adobe texture. Sweet clover, Hungarian vetch, and barnyard manure have increased the rate and depth of absorption of irrigation water by these heavy soils of low permeability. Advisory correlation work has been done in cooperation with the branch experiment stations at Burns and Hermiston, where experiments on the use of water are under way.

Special investigations.

Soil correction trials. Experimental plots have been retreated and studies are being continued in the improvement of black sticky or Cove clay. A special study is being made of the characteristics of the colloidal fraction of typical heavy Willamette Valley soil profiles, including a study of chemical composition, colloid content, reaction, exchangeable bases, and flocculation.

Fixation of nitrates by legumes. A special study is being made to determine the amount of nitrogen added to soil from the growth of field peas, where cut off, where turned under for green manure, with and without inoculation, and with and without fertilization. Sterile jars are maintained to check the possible fixation of nitrogen independent of legumes by azotobacter. Soils from the Willamette river-bottom belonging to the Chehalis series and soils from the Eastern Oregon wheat belt are included in the study. Soil nitrogen determinations are made with each successive crop. Research is needed to determine the depth and activity of azotobacter in the wheat belt in fixing nitrogen. The field pea was chosen for this study because it is an annual crop and is the best legume for short rotation at the Harney Branch Experiment Station.

Methods of improving permeability in soils of heavy texture. Methods of improving permeability in soils of heavy texture and high colloid content have been studied for the past two years. Sulfur has aided flocculation of alkali soil, and lime and manure have been most helpful on acid soil. Flocculation studies with clay suspensions show response to these treatments.

Drainage by means of pumping from wells. A special study has been initiated in cooperation with the United States Division of Agricultural Engineering to test the value of drainage by pumping from wells, and the use of water in supplemental irrigation in certain irrigated valleys. Geological and soil conditions, water supply, well records, crop vegetation in relation to soil reaction of ground water, and the quality of the pumped water will be observed in connection with these studies which have been started in Baker Valley by Professor M. R. Lewis who has been engaged for cooperative drainage and irrigation investigations.

Utilization of peat soils. A special study has been initiated to learn the characteristics, fertilizer requirements, and methods of improvement for typical peat soils. The present work is centered on the peat of Lake Labish, Marion county. Analyses and preliminary pot trials show that this soil responds to potassium application, with marked increase in the yield and net value of crops, and improvement in quality of such crops as onions and potatoes. In recent years further difficulty has developed and additional studies have been initiated on the effect of fertilizers on the soil solution and reaction of these soils. Later it is hoped to establish cooperative studies of the effect of treatment on activity of microorganisms concerned in liberating plant nutrients. Preliminary results developed methods for purifying water extracts of the peat, and analyses indicate that manure, potassium, and lime, especially potassium nitrate, are helpful in increasing the potassium content of the soil solution, and the yield of mint.

Further studies are needed to determine the effect of fertilizers on the quality of peppermint oil obtained. Field trials under way will yield sufficient products from various treatments to permit these studies.

A large vegetative growth of fiber flax is obtained on peat. The fiber content, however, is reported to be rather low. The possibility of overcoming this condition by the use of potassic fertilizers is under investigation. Lime, manure, and potassium all improve the potash content of the soil solution, and increase the height and yield of fiber flax as well as of mint. The lime may operate to aid biological activity for liberating nitrate and potassium.

Nutrient requirements of fiber flax. The value of fiber flax increases greatly with length. Flax promises to be a crop of commercial importance. Fertilizer experiments under controlled and field conditions are being maintained to study the nutrient needs of this crop. Preliminary tests indicate that potassium is the most important nutrient for increasing the length, value, and quality of flax fiber. Potassium applied in association with some nitrate has made it possible to produce, under controlled conditions, flax plants four feet in length. Potash seems especially important in the early part of the growth period.

Value of iodine as a plant nutrient. Much of the soil of the Northwest is almost devoid of iodine. An experiment is started under controlled conditions to test the validity of the claim that Chilean nitrate, due to the trace of iodine contained therein, is of greater value than fixed nitrogen fertilizers. Growth of head lettuce indicates that one part per million or less of iodine will increase yields, while two parts or more is toxic. Further studies are needed to determine whether the iodine absorbed is largely converted into organic compounds. The study would then call for the aid of the nutrition chemist to determine whether it had special merits in animal nutrition or even human nutrition.

Replaceable bases in some Oregon soils. A study of exchangeable bases of typical Oregon soils shows that acid soils are likely to be low in replaceable calcium, because of the change of hydrogen for calcium and loss of the latter element by leaching; that heavier soil types probably have greater basic capacity, but not necessarily a larger amount of re-

placeable bases; that neutral soils tend to run high in percentage of replaceable calcium, and to function as good soil; that alkalinity results from a change of sodium for calcium and that alkali soils are abnormally high in exchangeable sodium, which causes alkalinity; and that both acidity and alkalinity can be retarded if not practically prevented by proper soil management.

Reaction profile studies. A study of samples from the different horizons of the soil profile taken from the upland fertility plots at the Astoria Branch Experiment Station shows that soil to be low in exchangeable calcium; even the weathered soil-material in the substratum is low in exchangeable calcium. Low exchange calcium correlates with high acidity. Lime is of primary importance in improvement as confirmed by the fertilizer plot yields. Other treatments applied have had little effect on the soil reaction.

DEPARTMENT OF AGRICULTURAL CHEMISTRY

INSECTICIDES AND FUNGICIDES

Work and expense involved in the control of insect pests and fungous diseases in this state as elsewhere are steadily enlarging. Constant vigilance is maintained by the department in keeping abreast of new developments in the manufacture of insecticides and fungicides and in proposing and trying out new combinations of materials that give promise of more effective control. Much attention has been given also to a study of the chemical and physical properties of certain materials that were known to be of great value in control work, but more or less erratic in their effectiveness. A few instances are cited.

Oil emulsions. In the use of mineral-oil emulsions, excessive burning of foliage correlates with oils of high sulfur content and also with those that contained the larger amount of unsaturated compounds. The remedy lies in the selection of oils for the making of emulsions that have been refined for the removal of sulfur and the unsaturated compounds. The use of mineral-oil emulsions is on the increase.

Adhesive properties of bordeaux and other copper compounds. During the season of 1926 and again in 1927 a study was made of the relative adhesive properties of various new bordeaux mixtures and other copper compounds in contrast with home-made bordeaux. The procedure involved thorough dusting and spraying of both potatoes and apple trees with subsequent chemical analyses of measured areas of the foliage and bark for their copper content. Results from applications to potatoes warrant no generalization. Chemical data obtained at intervals of one month for five months after applications to apple trees clearly indicate the superiority of home-made bordeaux in its adhesive properties. The adhesiveness of commercial brands was improved by the addition of casein spreader. The adhesive properties of insecticides and fungicides are scarcely less important than their toxic properties. Inquiry in this direction is being continued.

Spray residues. The years of this biennium will long be remembered by the fruit industry of Oregon as the ones in which the extremely vexa-

tious problem of spray residue removal from orchard products was squarely faced and practically solved. Machine wiping of fruit, hand wiping, or any modification of the two methods for the removal of spray residue below the amount tolerated on interstate shipment by Federal pure food officials, proved to be ineffective in most cases. Of the fifty or more chemicals tried experimentally early in 1926 in a hurried search for an effective solvent of spray residues, non-corrosive on fruit tissues through short periods of contact, water solutions of hydrochloric acid in concentrations of .25 to .75 percent proved to be safest and most generally serviceable. Its use literally saved the fruit growers the 1926 crop of the Rogue River Valley and aided materially in other sections of the state. The use of acid solutions in cleverly contrived washing machines was general throughout the Northwest in 1927.

Minor details of the washing process. Notwithstanding the general acceptance and use of the acid treatment in 1927 in preparing apples and pears for interstate and foreign shipments, several minor details remained for solution to render the process 100 percent dependable. The most recent laboratory experiments, however, indicate that the nullifying influence to solution of spray residue on the part of spreaders and accumulations on the fruit of wind-borne dust and grit can be overcome through the exercise of forethought at spraying time. Lime, in the form of hydroxide or carbonate, mixed with a spray, nullifies in a large measure the retarding action of spreaders and dust accumulations on the solvent properties of the acid solution at packing time.

The retarding influence to acid solution of arsenical residues of heavy and improperly timed applications of oil emulsions is a decided hindrance to 100 percent perfection in cleaning operations in packing houses. Since the lighter applications of emulsions yield to the acid treatment, growers, in spraying, must govern themselves accordingly.

The wax-like secretions on apples present still one more difficulty in the removal of spray residue by acid treatment. Harvesting before such secretions are strongly in evidence and immediate washing in acid solutions is strongly urged upon growers.

Laboratory tests and field experience have also extended the application of the acid wash for the removal of spray residue to other fruits than apples and pears. The treatment has proved to be practically perfect on cherries sprayed with an unusually large concentration of lead arsenate and molasses and water for the control of the cherry maggot. Gooseberries, too, have likewise yielded their excess of bordeaux mixture, applied for the control of mildew and anthracnose, to the acid treatment without harmful effect. It is estimated that at least 100 tons of gooseberries produced in the Willamette Valley in 1928 will be so treated before they are processed at the cannery.

ANIMAL NUTRITION

The resignation of one of the Station chemists late in 1926 to accept an appointment on the research staff of a large manufacturing company necessitated the discontinuance of his work on potassium metabolism and a restatement of the cooperative project dealing with the metabolism of

dairy cattle. A newly appointed chemist was placed in charge of nutrition investigations in January, 1927. The program of work with dairy stock is in cooperation with the Dairy Husbandry department. At present it involves a study of the nutritive properties of alfalfa, especially from the point of view of rations restricted solely to the alfalfa plant.

Metabolism experiments. One phase of the metabolism experiments consist in a study of calcium, phosphorus, and nitrogen metabolism of dairy cows that for extended periods have been restricted largely or entirely to alfalfa hay. Twelve balanced periods for calcium, phosphorus, and nitrogen on alfalfa fed with and without supplements of starch, linseed-meal, and disodium phosphate have been completed. In these periods cows producing a moderate amount of milk on rations consisting principally of alfalfa hay have usually shown a positive calcium balance, a negative phosphorus balance, and frequently also a negative nitrogen balance. By supplementing the hay ration with disodium phosphate it has been possible to obtain positive phosphorus balances. Whether nitrogen is in positive or negative balance seems to depend somewhat upon the qualities of hay fed. The results of these experiments with such practical applications as seem to be warranted are soon to be published.

Biological value of alfalfa proteins. Another phase of this general problem in animal nutrition deals with the biological value of alfalfa protein. The preliminary investigations employ rats. Notwithstanding certain difficulties involved in the maintenance of these animals on such bulky rations as result from the necessarily liberal use of alfalfa leaves, some progress is to be noted in getting a line on the biological value of these mixed proteins. Growth curves resulting from the addition of small amounts of cystine to rations whose only proteins are those of the alfalfa leaves clearly indicate incompleteness in the matter of this important amino acid.

PRUNE STANDARDIZATION

Substantial progress is to be noted in cooperative work with the By-Products division of the department of Horticulture, whose objective is a system of grading for dry prunes that will insure a reasonable uniformity of quality of fruit within the several grades. Many chemical analyses have been added to those noted in the 1926 report. It is believed that a correlation of results warrants recommendations of a system of grading based on gravity separation of the crop previous to drying. That recommendation doubtless will be made in the near future.

SOIL SURVEY

This biennium brings to a close the chemical work originally undertaken in cooperation with the Soils department in a survey of agricultural lands in the Willamette Valley and Lower Columbia River Valley counties. Samples of Marion county soils were the last to reach the laboratory for chemical analyses. It is believed that this work will prove to be fundamental to a better understanding of the agricultural possibilities of the commonly occurring types of farm lands within the areas noted.

There is much to be accomplished still, however, through cooperative effort in making practical applications of the results of field and laboratory work.

DECAY OF FRUIT IN STORAGE

Decay of fruit, especially apples, in storage results in enormous losses yearly to growers and shippers. The cause of decay has been pretty well understood, but preventive measures have not kept pace. The cooperative undertaking of this department with the departments of Horticulture and Plant Pathology aims at the solution of preventive measures. The activity of this department in that direction consisted entirely of a search for disinfecting chemicals and some chemical tests to determine the practicability of their use in fruit disinfecting solutions previous to its storage. Of the fifty or more chemicals possessed of disinfecting properties and suggested for trial, formaldehyde has thus far proved to be the most feasible for commercial use. Chemical tests reveal practically no loss of the disinfectant from the solution used at temperatures of 60°, 80°, and 110° F. These temperatures cover the range over which disinfecting solutions are most likely to be used. Tests of the solutions before and after the dipping of one hundred boxes of fruit also indicate practically no loss in the concentration of the disinfectant. Cost of treatment will be negligible. Whether or not such treatment is finally to be recommended is still to be decided. It is interesting to note in this connection that the acid treatment of apples and pears for the removal of spray residue in itself has noticeably lessened storage losses from decay.

OTHER DEPARTMENTAL ACTIVITIES

Enforcement of state control laws.

Fertilizer and agricultural lime inspection. In carrying out the provisions of the Oregon Fertilizer and Agricultural Lime Laws, approximately 150 officially collected samples have been analyzed. In addition to these, about 25 samples have been received from various persons throughout the state, and chemical tests have been made on them also, in order to give the information asked for. During the 1928 fertilizer season, more than the average of officially collected samples were found to be below the guarantee of the manufacturer in one or more of the essential constituents. In all cases, the attention of the manufacturer or dealer was immediately called to the discrepancy. Faulty mixing and not fraudulent intent accounts for practically all of the differences noted.

Inspection of economic poisons. In accordance with the provision of the Oregon Economic Poison law, about 200 different insecticides, fungicides, and weed killers have been officially inspected and analyzed. Where certain brands of liquid lime-sulfur have previously been found to be below the guarantee of the manufacturer in active ingredients, the work of this biennium shows decided improvement. Only one or two samples have been found short of their guarantee.

Miscellaneous.

Application for a public service patent. It should be noted that in connection with other activities relative to the solution of spray residue

problems application has been made in the name of Robinson and Hartman for a public service patent covering the removal of spray residue by certain chemicals.

Supervision of spray residue removal. Urgent requests on the part of producers of all large fruit-producing sections within the state for chemical supervision of spray residue removal by the acid treatment have been met in a manner that appears to have given general satisfaction. A total of at least twelve months time on the part of one man has been given to the work in the past two seasons. It is believed, however, that within another year or two, the acid washing process will have been perfected sufficiently in all its many details to require no more technical supervision than can readily be arranged for locally in each producing section.

Cooperative work. Some chemical investigations of soil compounds have been undertaken at the request of the superintendent of the Southern Oregon Branch Experiment Station. The objective is some hint as to the cause of a tree affliction commonly called "little leaf." The results of chemical work to date, at least, must necessarily be interpreted in the light of results from some recently instituted work on the Station farm involving controlled nutrition of young trees.

The man power and laboratory facilities of the department are taxed to the limit at times in meeting requests of other departments and branch experiment station superintendents for cooperative work or for chemical assistance on some phase of a major project.

DEPARTMENT OF BACTERIOLOGY

Microbiological study of certain Oregon soils having an acid reaction. During the biennium research on this project has been concerned especially with (1) the relation of lime and fertilizer treatment to the amount of nitrate accumulating in field soils and the nitrate producing powers of these soils as measured by laboratory methods, (2) the relation of liming and fertilizers to the ability of these soils to fix atmospheric nitrogen through the agency of the non-symbiotic nitrogen-fixing organisms in the soil, and (3) the depressing effect of varying quantities of organic matter of wide carbon-nitrogen ratio on the nitrate content of the soil and the amount of nitrate necessary to add to the soil in order to overcome it.

Relation of liming and fertilizer treatment to nitrate formation in soils. Under field conditions the influence of climate and crop grown on the soil plays a big part in determining the amount of nitrates present. Low soil temperatures and excessive moisture retard nitrate formation during the winter and spring months to the extent that not more than a trace of nitrate can be found in soil under growing cereals. This humid season breaks suddenly into summer and soon lack of moisture is the limiting factor. The fact that no excess of nitrates can be found in the soil during the growing season of cereals indicates the need of a fertilizing system which would increase the supply of nitrates to growing crops during the winter and spring months.

Lime causes an increase in the nitrate content of fallow soils and also the nitrifying power of the soil as measured by its ability to produce nitrates from nitrogenous amendments in the laboratory. Climatic factors, however, which affect soil moisture and temperature are limiting factors which mask results and make it impossible to predict crop behavior.

The validity of nitrification tests commonly used in the laboratory for actually showing the true difference that exists in the power of soils to produce nitrates has often been the subject of severe criticism. Some investigators have attempted to standardize these methods and overcome the criticisms by using several methods simultaneously.

Nitrification studies have been made on two soil types from experimental plots of the Oregon Agricultural Experiment Station which represent extreme variations in physical and chemical properties. In these studies four methods were used simultaneously.

The plots at the Corvallis Station are located in a humid belt on well drained, silty clay loam, and represent a dark soil well supplied with organic matter and with a normal hydrogen-ion concentration approximating pH 5.3. These plots have been under fertilizer treatment since 1914.

The plots of the Hermiston Branch Station are located on medium sand which, being light and arid, is naturally deficient in organic matter. This soil has a normal H-ion concentration approximating pH 7.2. These plots are irrigated, receiving approximately four and one-half feet of water annually. The plots have been under fertilizer treatment for three years.

Only modifications of the soils method for nitrification tests were used as follows:

1. Nitrification of the soil's own nitrogen, 100 gms. of soil incubated at optimum moisture for 28 days.
2. Nitrification of ammonium sulfate in soil, 30 mgs. of NaS ammonium sulfate in 100 gms. of soil and incubated for 28 days in optimum moisture.
3. Nitrification of ammonium sulfate in the presence of 210 mgs. of calcium carbonate.
4. Nitrification of organic nitrogenous materials 0.1 percent of blood meal incubated for 28 days.

On the Willamette silty clay loam soil methods 2, 3, and 4 showed a very close agreement. Parallelism between the fluctuations in the nitrifying powers of the various plots are uniform. Nitrates produced from the soil organic matter fluctuate within extremely narrow limits.

Nitrification tests on the medium sand do not yield consistent results when the same amounts and kind of nitrogenous materials are used as above. Shortening the period of incubation does not overcome this lack of agreement. Either the buffer quality of the soil, or lack of residual effects of the fertilizers added, may account for the failure of the nitrification tests under these extreme conditions. Studies were made in which varying quantities of ammonium sulfate and varying incubation periods

were used to check further on the effect of ammonium sulfate on normally productive sandy loam, loam, and clay loam soils. Here it is found that the buffer capacity of these soils was adequate to take care of the acidity formed from nitrification where 30 mgs. of nitrogen as ammonium sulfate was used. Smaller applications of ammonium sulfate were quite satisfactory for determining the nitrifying powers of these soils, but correspondingly shorter incubation periods should be used.

Relation of lime and fertilizers to non-symbiotic nitrogen fixation. Soils of the fertilizer plots of the Corvallis Station which are located on Willamette silty clay loam have been studied in the laboratory to determine the ability of these soils to fix atmospheric nitrogen through the agency of the non-symbiotic organisms in the soil. Incubation studies in which Ashby's mannite solution was inoculated with soil and also analyses of soils to which mannite had been added show that these soils have a very low nitrogen-fixing power. Despite the fact that these soils have been under fertilizer treatment for fourteen years, during which time they have been maintained at a wide range of soil reaction, the azotobacter group of organisms are apparently lacking.

Further investigations were made in which six different types of virgin Willamette Valley soils representing as wide a range of soil drainage, fertility, and reaction as possible were tested to determine their nitrogen-fixing powers in the presence of lime, phosphorus, and artificial inoculation with azotobacter. These soils fixed very little nitrogen and in none of these soils was there any indication of the presence of the azotobacter group of organisms.

Since the nitrogen-fixing power of these six typical Willamette Valley soils is low and these preliminary investigations fail to indicate the presence of the azotobacter group of organisms it seems very necessary that this phase of the project should be further investigated with the view of ascertaining what fertilizer treatments and cultural practices should be followed in order to make the soil a favorable culture medium for the growth of these nitrogen-fixing organisms.

Depressing effect of organic matter of wide carbon-nitrogen ratio on the nitrate content of the soil and the amount of nitrate necessary to add to the soil in order to overcome it. Preliminary studies have been made in which varying quantities of wheat straw, alfalfa and green kale were added to Willamette silty clay loam in the presence of variable quantities of sodium nitrate. These studies were carried on in the laboratory where half-gallon jars each containing 1 kilogram of soil served as containers. During the early part of this experiment the soils were analyzed for nitrate nitrogen at one-week intervals; later the period of incubation was extended to two-week intervals. All the soils treated with organic matter showed a marked decrease in the amount of nitrates present. This depression lasted longest with the straw, but was of short duration where alfalfa and kale were applied. It is the intention to follow up these studies so as to determine the relationship between the amount of nitrate and organic matter added to the humus produced.

Nitrogen metabolism of nitrogen-fixing bacteria. Studies have been made concerning the mechanism of nitrogen fixation by legume bacteria

and azotobacter. Chemical analyses of cultures grown on synthetic media for varying periods of incubation indicate that the amount of amino nitrogen increases with the age of the culture up to a given point. Qualitative tests indicate the presence of tyrosine or oxyacids in all the cultures studied. Neither nitrates nor nitrites could be detected at any time in vigorously growing cultures when the reagents used in making up the media were free from these compounds. The fact that an accumulation of ammonia always occurs in the cultures during the first few days of maximum growth and gradually diminishes as the available carbohydrate is reduced leads to the conclusion that ammonia is probably the first product of metabolism in nitrogen fixation and that a balance is reached quickly within the cells in which the ammonia is formed no faster than it is synthesized into protein.

Cultures for legume inoculation. During the biennium 1926-1928, cultures sufficient to inoculate 15,000 acres of land were sent out by this department. This amount varies somewhat with the seasons and it was particularly affected by the adverse planting seasons of 1927-28. The cold, wet spring stimulated the planting of cereals and decreased the acreage of legumes.

Observations and reports indicate that inoculation often means the difference between success and failure of the crop. Especially is this true where alfalfa is being introduced extensively into the Willamette Valley. The cultures sent out by the department of Bacteriology are large, show vigorous growth, are freshly prepared when sent out, and each year a new culture is obtained from the identical legume for which it is to be used. This new culture is tested for "virulence" under carefully controlled conditions before being used.

Vaccines for hemorrhagic septicemia. The department has sent out more than 20,000 doses of vaccine for hemorrhagic septicemia in cattle and sheep. This disease continues serious in certain areas of the state, but it is apparently controlled by the vaccine. Where the disease is endemic the practice of vaccination is quite general and reports are uniformly favorable when the diagnosis is correct. The reports, however, come from farmers and veterinarians in the field and cannot be considered entirely authentic. There is need for carefully controlled experimental work among the diseased flocks and herds.

Sanitary tests of water. A total of 1,750 tests of water were made by the department during the biennium. The requests for this service come from individuals on the farms and in the small communities and from water companies publicly and privately owned. Besides making the test, attempt is made to remedy conditions where the water shows contamination. This service is resulting in marked improvement in the water supplies throughout the state and people are generally much more aware of the importance of pure water, but there is still much to be done.

Sanitary tests of market milk. The department made approximately 2,000 bacterial analyses of milk during the biennium. The requests for this service are continually increasing, and the amount of work done is

limited only by the facilities of the laboratory and time of the staff. This work is done independently and also in cooperation with the State Dairy and Food Commission, which has no facilities for doing bacteriological work. In addition to the educational work, an attempt is now being made to complete a survey of market milk supply of the state. Since undertaking this work several years ago, there has been a marked improvement in the milk supply of the western part of the state particularly. Very little work has been done in Eastern Oregon, but the need is great.

Clinical diagnoses. Approximately 1,000 clinical analyses were made during the biennium, most of them on the campus and locally. No attempt is made to expand this work, which is definitely of a public health nature, but the department serves the College, the county, and to some extent the surrounding counties.

DEPARTMENT OF FARM MANAGEMENT

The present biennium is the first time this department of the Agricultural Experiment Station has had funds sufficient to undertake a real program of work and carry it through in a substantial, thorough way. All the field work in three major and two minor projects has been brought to a conclusion during the biennium. Two years of field work have been done on an additional major project. The following is a brief statement of the respective projects and the status of the investigations on each.

Cost and efficiency study of Oregon prune production. Four years of field work have been completed on this project and final manuscript is in preparation. The study has involved 111 bearing orchards in the Willamette and Umpqua valleys, containing more than 2,500 acres of bearing trees producing 2,500 tons of dried prunes annually.

A mimeographed progress report has been issued each year. The manuscript in preparation will report the combined results of four years.

Cost and efficiency study of Rogue River pear production. Three years of field work on this project have been completed and a manuscript for publication is in preparation. The field survey has covered sixty representative pear orchards containing 2,500 acres of bearing trees producing approximately 260,000 boxes of pears annually. A progress report has been mimeographed each of two years. The manuscript in preparation will combine the results of the three years.

Cost and efficiency study of Oregon forage enterprises. Three years of field work have been completed and manuscripts for publication are under preparation. A total of 850 cost records have been taken, combining 25,000 acres and producing about 83,000 tons of forage annually from representative farms in all parts of the state. Progress reports have been mimeographed combining the results of field work in 1925 and in 1926. The manuscript in preparation will combine the results of the three years of field investigations.

Cost and efficiency study of commercial egg production in Oregon. Two years of field work have been completed on this project. The field survey has included records for 134 farms covering the cost of producing more than one million dozen eggs from eighty thousand hens, representing every commercial poultry section of the state. A progress report was mimeographed combining the results of field work during 1926. Results of the field survey in 1927 are being compiled. The project plan includes one more year of field work.

Economics of strawberry production. Two years of field work have been completed on the cost-of-production phase of this project, and two years of field study and plot study have been carried out by the department of Horticulture to obtain special data on varieties and cultural practices to supplement the cost data. A manuscript is already prepared for publication reporting the results of the study.

Cost, efficiency, and price study of Oregon apple production. Price history study has been completed in cooperation with the department of Horticulture and the Bureau of Agricultural Economics. Manuscript reporting the results has been prepared.

The foregoing projects have been carried out in cooperation with the respective commodity departments. The Farm Management department has been responsible, however, for the general plans and compilation of data.

Cost of producing wheat and use of combines and tractors on dry farms of the Columbia basin. The field work on this project in cooperation with the Federal Bureau of Agricultural Economics was completed prior to the biennium. During the biennium, however, the United States Department of Agriculture bulletin 1416, The Cost of Producing Winter Wheat and Incomes From Wheat Farming in Sherman County, Oregon, and bulletin 1417, The Cost of Using Horses, Tractors, and Combines on Wheat Farms in Sherman County, Oregon, were issued.

These bulletins report results from three years of study, covering 150 wheat farms. With R. S. Washburn of the Federal Department, senior author, the chief in Farm Management of the Oregon Agricultural Experiment Station is joint author.

In each of the foregoing projects the economic needs of the enterprise or type of farming under study have been fully and carefully covered. The purpose has been to obtain information which will serve as a sound basis for a program by Extension workers and the farmers, especially where the reorganization of the individual farm business or a type of farming appears necessary to establish a more profitable business.

The demand for data from such studies is increasing. There are a number of pressing problems which should be undertaken at the earliest moment possible. During the first half of 1928 attention has been directed largely to the final compilation and preparation of manuscripts covering the investigations for which field work has been completed. It is planned to continue this effort until these projects are reported in printed form. This will reduce somewhat the field work of the next biennium.

DEPARTMENT OF AGRICULTURAL ECONOMICS AND MARKETING

Additional investigations in agricultural economics under Purnell funds were started during the calendar year 1927. This is the first organized work under the department of the College known as Agricultural Economics and Rural Sociology. Station work in farm management, cost of production, and enterprise surveys have been under way in the department of Farm Management since 1925.

Following is a brief statement by projects of the new work undertaken.

Relation of assessed values to sale values of real property in Oregon. This investigation was started in April, 1927 and completed and published in June, 1928.

The investigation involved a study of records affecting approximately one-ninth of all the real property in the state of Oregon, during the period 1921 to 1926 inclusive. During this period the government stamp tax on dates followed approximately the consideration involved in the transfer. The assessed valuation for the corresponding year was made available by the State Tax Commission.

This study is considered the most exhaustive of its kind yet carried out in Oregon. The results have been published in Station Bulletin 233, A Study in the Ratios of Assessed Values to Sale Values of Real Property in Oregon. A digest of the bulletin is given under Publications.

Marketing Western Oregon wool. This project was undertaken in July, 1927. The annual output of wool in Oregon is about sixteen million pounds. Most of this total output is marketed in the East, yet there is an Oregon mill consumption of eight to ten million pounds annually. The aim of this project is to find out the source of supply of local consumption, the types of wool which make up this supply, the amount of foreign material used, and the price relation between these different types of wool on the local and Eastern market.

The data on Western Oregon wools have been brought together and are now being compiled for a final report to be completed within the next few months.

Canning of fresh and dried prunes with special reference to increasing the market for Oregon prunes. This project was undertaken by the department of Economics and Sociology in cooperation with the department of Horticulture. The object of the study is to examine the possibilities of increasing the market for Oregon prunes by greater development of canning production.

Phases which have been under study include:

(1) Study of figures affecting the demand for canned prunes, including prices paid by consumers and preferences of consumers. The preference, for the present, will be confined to the state of Oregon.

(2) Studies of figures affecting the readiness with which the supply of canned prunes may be adjusted to meet changes in demand, including

cost of production, capacity of plants, size and quality of prune crop, and demand for prunes other than canned.

(3) Study of the product, including a study of the trade names, grades, and size of cans.

(4) Study of trends in price of production.

(5) Study of marketing practices, including selling methods, destination of the goods, storage, advertising, and others.

(6) Study of horticultural problems affecting yields, size, and quality of fresh prunes, and the influence of the method of packing and canning on the quality of the prunes.

Canneries throughout the state have been visited personally, and the proposed data have been collected relative to cost, plant capacity, market conditions, and supply of raw prunes. The data have been obtained also on the price and production trends of marketing practices.

Compilation of the information collected is nearly completed. Final report and publication of the material, if suitable, should follow within a few months.

Study of membership problems and growers' attitudes in centralized cooperative associations. This project was undertaken by the department of Economics and Sociology in cooperation with the Federal Bureau of Economics. The object is to obtain by personal interview from growers their attitudes toward cooperative marketing associations, and the marketing problems connected with the distribution of wool whether marketed cooperatively or otherwise.

The field work was started June 1. The representative of the Oregon Agricultural Experiment Station has taken approximately 130 individual records distributed throughout Western Oregon. The representative of the Bureau of Agricultural Economics has taken records in Southern and Eastern Oregon. Tabulation and compilation of data will be undertaken at once.

DEPARTMENT OF HORTICULTURE

Research and experimental work has been carried on in the sections of Pomology, Vegetable Gardening, and Horticultural Products during the past biennium. As a whole, progress has been satisfactory and a considerable volume of work has been accomplished.

The most outstanding accomplishment of the biennium has been the solution of the spray residue problem. This problem came as an emergency measure during the winter of 1925-26 when Great Britain announced it would embargo American fruits, especially apples, that did not test below .01 grains of arsenous oxide per pound of fruit.

Early in the spring of 1926 the Station suggested that some sort of acid wash might remove the arsenate spray residue and solve the difficulty. Station chemists found later by trials of many other acid substances that hydrochloric acid was effective and least liable to injure the fruit.

In early summer as the magnitude of the project appeared, the department of Horticulture and the horticultural branch stations at Talent

and Hood River joined the chemists in the research work. Chemical analyses of apples and pears were made throughout the picking season in the various fruit-growing districts of the state. Methods and devices and many chemicals for cleansing fruit were tried out. The closest cooperation between Station workers and the State Dairy and Food Commission, the United States Bureau of Chemistry, and equipment manufacturers was maintained; and the growers, in most instances, realized the importance of the work and cooperated in every way possible.

Further work was carried on along similar lines during the season of 1927, and some difficulties, chiefly in types of washing machines, were encountered, but in general the needs of the work were better understood by all interested, and much progress in the practical application of washing was made.

The small fruit washer developed by the Station proved a boon at Hood River in the fall of 1927, when the submerger type of washer had to be abandoned. Twenty-eight of these paddle-type machines were in use at the close of the packing season. Approximately 70 percent of the fruit from the Apple Growers' Association at Hood River was washed in these machines.

In view of the fact that washing in acid cleans the fruit not only of arsenic but also of lead, copper salts, earth, etc., at a very reasonable cost, introduction of this method of cleansing may be looked on as a blessing in disguise. The cash value of the apples and pears washed throughout the United States during 1927 was approximately $45,000,000.

The research of the department resulted in another accomplishment of outstanding economic value as a result of the work on pears at Medford. A method has been found for the storing and ripening of Bosc pears. It is conservatively estimated that this discovery is worth a quarter of a million dollars annually to the pear industry of Oregon.

Blueberry culture. Thirty-four plants of eight different varieties were planted December 22-23, 1925, one half on a rich loam soil and the other half on a sandy peat soil at Waldport, Oregon. It is desirable to introduce this fruit if it is economically feasible to do so. During the growing season of 1926-27, most of the plants thrived, especially on the sandy peat soil, and in 1927 bore some fruit.

Repeated attempts at propagating from cuttings have been practically failures. Until plants can be propagated and grown more cheaply than at present, the future of this industry does not look bright. Work will be continued with the special object of discovering cheaper methods of propagating blueberry plants.

Culture and testing of perfume roses. Work was begun on this project in the fall of 1927 in cooperation with the Office of Drugs, Poisonous and Oil Plants of the Bureau of Plant Industry, United States Department of Agriculture. The experiment was started in response to the appeal of the Perfume Manufacturing Association and funds were contributed by this Association.

The object of the experiment is to determine whether roses for perfume and oil purposes can be grown in this country as well as in Europe

and whether the cost of production and handling can be kept low enough so that a rose perfume industry can be built up in competition with Europe.

One acre of land has been assigned to the work. Most of the land was planted during the past fall and spring. The remainder will be set to the varieties chosen as soon as these can be obtained from the trade, which is expected to be in the fall of 1928. The Ulrich Brunner rose has been chosen for the principal planting. Other varieties will be grown for comparison in growth habit, production of petals, richness of perfume, etc. Distillation of the perfume will be supervised by United States Department of Agriculture workers.

Cost of producing pears in the Rogue River Valley and some factors influencing profits. In this work the departments of Horticulture and Farm Management are cooperating. A full report of this project is included under the department of Farm Management.

Commercial apple industry study. This is a cooperative project with the departments of Horticulture and Farm Management of this Station and the Bureau of Agricultural Economics of the United States Department of Agriculture. During the summer of 1927, work was begun by the department of Farm Management on the price-history phase of the enterprise. Full particulars concerning the project are reported under that department.

Pruning as a factor in crop differentiation. During the past two years work on this project has proceeded along two lines.

First, growth correlation studies in apple and pear trees. This study of the factors involved in growth correlation connects directly to the growth of apple-shoot studies, reported in Station Bulletin 200. A Study of Growth in Summer Shoots of the Apple with Special Consideration of the Role of Carbohydrates and Nitrogen. Until the present time the results obtained on growth correlation do not appear to justify publication. Numerous observations and experiments have been made. Experimental methods have been largely confined to the observation of the responses to injury, such as ringing, defoliation, and disbudding. Many micro-chemical examinations have also been made, but one series only of quantitative analyses has been undertaken. It has been felt that more definite leads than any yet found should precede such detailed chemical work.

The second line of attack in this project is the study of the behavior of phloridzin in the apple tree during the dormant and the awakening periods. Another phase of this has been the study of the responses of apple shoots to various anaesthetics as regards alteration of their phloridzin content. The purpose of these studies is to determine the function of phloridzin in growth and reproduction. All these observations have involved much quantitative chemical analysis, combined frequently with micro-chemical examinations. This latter incidentally has necessitated the working out of new micro-chemical methods.

Fruit harvesting and handling. This work was begun in 1924 in response to the urgent demand of growers for more information relating

to harvesting, classification, and storage of fruits. Pears, especially the Bosc variety, Italian prunes, sweet cherries, apples, and red raspberries have been dealt with in this investigation.

The Southern Oregon Branch Experiment Station and the Hood River Branch Experiment Station have cooperated in the work. The United States Department of Agriculture, Bureau of Plant Industry, also cooperated in the work with the Bosc pear.

Pears. During the biennium, observations on pears were enlarged so as to include Comice, Anjou, Bartlett, Howell, Seckle, and Winter Nelis in addition to the Bosc variety. The publication of Station Bulletin 228, Investigations on the Harvesting and Handling of Bosc Pears from the Rogue River Valley, July, 1927, practically terminated the phase of the project dealing with Bosc pears. As a direct result of this work with the Bosc, it can be said that a practical and efficient method of storing that variety has been found. As has already been pointed out, this method, when fully applied, will mean a large saving to the state. There has been considerable work done on the handling of Bartlett pears for canning purposes. This work was requested by the Northwest Canners' Association.

Cherries. Work on sweet cherries has now been carried through four seasons and the experimental work is practically completed. The experimental data seem to indicate conclusively that maturity and quality of sweet cherries can be accurately determined by testing the juice of the cherries with the Balling scale for sugar. Differences of from 10 to 12 percent are often noted between cherries picked the first of the season and those harvested later in the season. The work with sweet cherries during 1928 will be largely checking up on former experiments. At the end of the season it is expected that there will be sufficient data for publication.

Canners are now asking that some work be done on the harvesting and handling of sour cherries, and it is hoped that sufficient funds may be available for this work in the near future.

Prunes. Studies dealing with the harvesting of Italian prunes for canning and fresh shipment were started in 1924. A progress report was issued in 1926. As a result of this work a test of maturity for Italian prunes has been developed. This is similar to the pressure tester used in testing the ripeness of pears, except that the plunger is 6/16 inch instead of 7/16 inch in diameter. This test is now being used by the industry in determining the time of picking for fresh fruit shipment. It is planned to continue the tests with prunes during the coming season.

Red raspberries. Work on red raspberries was done at Hood River during the season of 1926. Tests were made to determine quality and maturity of berries by the sugar content of the juice, with negative results. The results thus far obtained indicate that the failure of raspberries to stand up after picking is due largely to improper handling in the field. No work on this project was carried on in 1927 and it is not thought practicable to continue the work through 1928.

Apples. Work on the harvesting and storing of apples was started at Hood River in 1926. The spray residue situation, however, greatly interfered with this phase of the project. Considerable work is planned for the coming season, which will include a test to determine the relation of maturity to the canning quality of apples. It is planned also to do more work in the handling of apples from the Willamette and Hood River valleys. It is expected that a mimeograph circular dealing with the harvesting of apples under Hood River conditions will be published in the near future. The peculiar conditions now existing in this district demand special attention.

Spray residue. Storage experiments to determine the effect of the various cleansing treatments on the fruit were conducted during the past year. The results of these tests will be published soon in the form of a new bulletin on spray residue.

This project was attacked as an emergency measure to the handling-of-fruits project and has been closely coordinated with work on harvesting and storage of apples and pears.

Arsenic injury. Some very striking results on the control of arsenic injury in apples were obtained during the year. Because of the significance of this problem, especially in the Hood River Valley, it is planned to push the work as rapidly as possible during the coming season. It is hoped that one year more may complete this phase of the project.

Improvement of prune orchard conditions. Many of the older prune orchards, especially in the Willamette Valley, have been bearing poorly for several years and seem to lack in vigorous growth. At the insistence of the Salem Chamber of Commerce, improvement work in two of the older Italian prune orchards was started in the vicinity of that city in the spring of 1926. The orchards in which this work is being carried on are more than thirty years of age and the trees are set rather closely. The improvement work has been in the nature of fertilization of the soil with different materials, coupled with heavy pruning of the thinning-out type, and good cultivation. The growth and bud development on these trees has been greatly stimulated and increased in most instances, indicating much greater vigor for fruit production. One excellent fruit crop has been produced on this orchard since the experiment began and the blossoms in 1928 were exceptionally heavy. The fruit crop this year, however, has been practically ruined by rainy weather during pollination time.

Influence of irrigation on small fruits. Approximately 100,000 acres in the Willamette Valley are thought to be fitted for irrigation and have soils suited to small-fruit production. Little of this land is now in use for such purposes. It is proposed in this investigation to determine whether irrigation on the sandy loam river-bottom land will be feasible and profitable.

Plantings for this project were made in March, 1926, but the plantation is not yet old enough to give any data of value.

Strawberry breeding. For several years breeding work with strawberries has been carried on at the Station. In the spring of 1927, also in 1928, several thousand plants of four kinds, which gave considerable promise at the Home Station, were distributed for trial with growers. They have not yet been on trial long enough to give any results.

Cherry breeding. A few seedling cherries out of the large number once started on the Agricultural Experiment Station grounds are still being held as having possibilities. In a few cases the quality has been excellent but the yield very light. This was due to lack of proper pollination. During the past two years a search has been made among the named varieties of cherries and seedlings to obtain pollenizers for these exceptionally fine cherries. In the case of two or three of the most promising seedlings this has been accomplished with very satisfactory yields resulting.

Walnut seedling trials. During the last two years several promising walnut seedlings have been propagated from the seed sent in by growers throughout the state. As the walnut is naturally slow in coming into bearing, this will be a long-time proposition. It is hoped, however, that some of the seedlings may prove themselves worthy of asexual propagation and thus widen the number of varieties which can be grown in the state. At the present time only one or two main varieties have been highly successful with growers.

Greenhouse tomatoes. For a number of years the pollination of greenhouse tomatoes has been a serious one for growers. When pollination work was first taken up by the Oregon Agricultural Experiment Station several years ago, the question of methods of pollination was one given close attention. The varieties used at that time were largely of American origin. Since then, a wider selection of types has been made and several varieties have been introduced from England. Some of these are much more self-fertile than are the American varieties. In recent years a large part of the experimental work has been to determine the relative value of these English and American types in regard to self-fertility, yields, and general market appearances. Some varieties of English origin, such as Sutton's Best of All, show a high percentage of self-fertility.

Costs of previously used methods of pollination—the emasculation process—have been determined as approximating 3½ to 4 cents per plant. These costs will be largely eliminated if self-fruiting types of tomatoes can be substituted.

In the so-called self-fruiting types, all that is necessary seems to be a shaking or jarring of the clusters of blossoms in order to produce a satisfactory setting of fruit. The Best of All variety is valuable also in bearing fruit that is very firm, uniformly colored, and of desirable size.

It is planned to continue investigations regarding the value of these variety types with and without artificial pollination, to study the flowering and fruit forming characters, and to ascertain the fundamental causes of self-fertility of various varieties.

Seed strain tests.

Beets. Studies have been made for several years of different strains of beets for canning purposes. Cannerymen are desirous of obtaining a strain of the common beet used for canning, namely, the Detroit Dark Red, showing as little zoning or ringing of light colors as possible. The object of this experimental work has been to contrast the relative value of different strains of this variety and to investigate the factors that affect the color of the roots for canning. Of the different strains tested, a wide variation has been found in the suitability for canning. This percentage may vary from 96 percent usable roots in one strain to 55 percent in another, the average usable roots being 82 percent.

Light sandy loam soils in the trials produced a larger number of colored roots than the silt loam or heavier soil types. The percentage of usable roots of three different strains was from 5 to 13 percent greater when grown on silt loam soil than when grown on the sandy loam soil.

Other factors, such as commercial fertilizers and irrigation water, have been tried within the past two years to determine their influence. This phase of the work will be continued in the future together with the soil and seed strain trials.

Carrots. Studies have been made of several varieties and strains of carrots for canning purposes. Undesirable carrot strains have lighter centers or, in some cases, green cores. Various domestic as well as imported strains of Chantenay carrots, most widely grown, have been produced with a view of comparing strains and a possible isolation of the best strains under observation. Several other varieties of imported types have been grown also, among them the Giant Flakee, which gives promise of being unusually valuable.

It is planned to continue these tests.

Irrigation of vegetables. There are thousands of acres of land in Western Oregon so situated that they can be irrigated for vegetable production. With a view of determining whether irrigation would be profitable under our conditions of rainfall, experiments were begun in 1926, irrigating such common vegetables as cabbage, squash, corn, peppers, and several other crops. For checking purposes similar crops were grown without irrigation. Of the crops grown in 1927, sweet corn showed a net increase when irrigated of $79 per acre over the unirrigated land. Costs include electricity used for pumping and the labor and seed, but do not include overhead charges.

A similar comparison of late cabbage showed a net gain per acre of $101.50 over non-irrigated cabbage. For squash the gain was $104.70 over non-irrigated squash.

It is planned to continue this work, enlarging it so as to include tests of the responses to commercial fertilizers under irrigation conditions.

Standardization of dried prunes. Dried prunes are sold entirely on a size basis. This method of sale is faulty because the consumer often pays high prices for prunes of large size but of poor quality, resulting in lowered consumption and a much smaller repeat business for the grower. Work was begun in 1925 to attempt to develop some means of

classification that would bring out such factors as quality, size, moisture content, keeping quality, and attractiveness of pack.

During the last three seasons analyses have been made on fresh as well as dried prunes. A wide range of sugars and acids have been found, although there is some relationship of the acid to the amount of sugar present. A method of sorting fruit in the dried state has been devised which is accurate enough but which is not cheap enough for practical purposes.

As moisture influences the grade to quite an extent, it has been found necessary to work with green fruits instead of dried fruits for the determination of quality. The fruit graded in the green state has shown a drying ratio from 4 to 1 to as low as 1.1 to 1, the higher ratio indicating a predominance of green fruit of much lower quality, due to under-maturity. Methods for testing green fruit in this way have been worked out so that they are both cheap and practical.

Heat penetration in the processing of prunes is an important factor in the keeping quality of the product. Work thus far on processors has shown the need for more flexible processors in plants now using live steam. These machines are not equipped to give proper sterilization and prevent contamination of good fruit packed in the same case with fruit infected with brown rot, mold, and other organisms. It has been shown experimentally that breakers are needed to separate the chunks of prunes going into the processor in order that better heat penetration may be obtained. Greater length of time in processing is necessary also in order to give the heat opportunity to penetrate to the centers of the fruit for perfect sterilization.

Work during the fall of 1928 will include the preparation of fruit by a mechanical process worked out in the laboratory and operated in the plant of a large prune packing association in the Willamette Valley. It is hoped that a device may be perfected whereby inspectors of dried prunes may be able to determine grades accurately and with reasonable economy.

Relationship of going in sirup to cut-outs in canned fruits. The work done thus far on this project has been for the purpose of obtaining information on the effect of seasonal factors in canned fruits. Cut-outs on goods packed have shown few changes of any consequence. The reason is obviously due to the fact that fruit obtained from growers varies in ripeness over a number of plantings in different localities. In a canning plant these fruits of different plantings from different soil conditions are blended, with the consequence that no decided change takes place in the cut-out as the season advances.

This project will be continued to determine if possible other factors which enter into the cut-out of canned goods.

Prunes and gooseberries. A cooperative project on prune and gooseberry sprays has been carried on with the department of Botany and Plant Pathology. The object was to obtain sprays for the control of mildew on gooseberries and brown rot on prunes, which would have no detrimental chemical effect on the tin containers used for packing the

products. The results of the prune work are ready for presentation, either in a paper or circular, during the coming year. Further work on gooseberries is desirable.

Cherries. Cooperative work with the section of Pomology on cherry and strawberry crosses is being carried on.

The bearing that ripeness of fruit has upon perforations of cans and sirup cut-outs of the pack is being investigated by this section. So far the work shows that cherries sorted for ripeness give better color, flavor, and more uniform sirup cut-outs. Further, the cans in the riper lots generally do not have the same tendency toward perforation as do those containing greener lots of fruit.

Cherries of lower maturity were light in color, showed considerable shrinkage in packing, and the cut-out of sirup was lower in sugars.

An experiment in preserving Royal Ann cherries in brine was undertaken during 1927. It has not been completed. The object was to determine the effect of varying solutions on the bleaching and keeping quality of the fruit.

Some interesting information was found as to perforation due to seam leaks. Half of each lot canned was carefully paraffined to seal any possible leaks of the seams. Those sealed in this manner showed less spoilage from hydrogen than those not paraffined.

Horse meat. Wild horses are now being slaughtered in Portland under U. S. Government inspection. At the request of packing establishments, the feasibility of canning the better meat for human consumption was investigated. Results thus far point toward a good product of fine flavor which can be sterilized in two hours at 240° F. for No. 2 tins, or in one hour at 250° F.

Confections. Various methods of candying fruit have been tried out. Results show that apples can be candied by starting them at a 32° Balling sugar solution to which a slight amount of citric acid has been added. Boiled slowly they gradually become saturated with the sugar solution. When they become transparent they are removed from the solution, rolled in granulated sugar, and dried in a cabinet kept at a temperature not exceeding 90° to 100° F. A good product has resulted from this treatment.

A satisfactory and delicious prune candy was devised by using finely ground dried prunes to which sugar at the rate of one-third the weight of the prunes was added and sufficient agar agar to tie the product together.

The agar agar, at least 2 percent by weight, was dissolved on a stove in a small quantity of water. Prunes previously ground with the sugar were added and the entire mass boiled ten minutes to sterilize. This product was then whipped into a mixture until the agar agar began to harden. The mass was poured into a mold and cut when cold. Dipped in chocolate it made an excellent confection.

Sample examinations. The Horticultural Products Laboratory has examined 399 cans sent in for purposes of determining the type of spoil-

age and has also passed upon about 60 samples of various vegetables, dried fruits, fruit juices, fruit sirups, carbonated beverages, and glassed chicken. Approximately a ton of fresh prunes from the Milton-Freewater district were canned for the purpose of determining the canning quality of the Italian prune grown in that section.

Decay in fruits and its prevention in connection with harvesting, storage, shipping, dipping, and disinfection. This is a cooperative project between the departments of Botany, Horticulture, and Chemistry. It is reported on under the department of Botany.

Canning of fresh and dried prunes in Oregon. This is a cooperative project between the departments of Economics and Sociology and Horticulture. It is reported on under the department of Economics and Sociology.

Commercial apple enterprise study. This is a cooperative project between the departments of Farm Management and Horticulture. It is reported on under the department of Farm Management.

Economics of strawberry production. During the summers of 1926 and 1927, field studies bearing on the cost of production of strawberries have been carried on with the departments of Farm Management and Horticulture cooperating. The object of the investigation was to show the influence of farm management practices and market prices on the profitableness of strawberry growing. Records from 192 farms growing strawberries were taken during this period, and a large amount of data were obtained bearing on the cost of production of strawberries.

A Station bulletin covering the work is in preparation.

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY

Progress as a whole in this department was satisfactory. Increase in cooperation from the Federal Department of Agriculture made possible the strengthening of investigations on potato diseases and bulb diseases. On the other hand, the absence of the head of the department on sabbatical leave during the last year of the biennium brought to the Station men more emergency problems and service work than in the ordinary year. Following is a brief statement of investigations by projects.

Virus diseases of potatoes. At the beginning of the biennium this project was made cooperative with the Bureau of Plant Industry and with the experiment stations of Utah and Montana. The regional study of this group of problems thus made possible has given a wider knowledge of these diseases and their control. Rugose mosaic remains the most serious and common virus disease of potatoes. Leaf-roll causes similarly heavy losses in affected plants but is not so generally prevalent. Mild mosaic occurs rather widely but the reduction in yield is not so great. Spindle tuber has been recognized in our commercial varieties grown here only twice and then in small amounts. Witches'-broom occurs in an erratic way usually in small amounts. Giant hill has been encountered in a few varieties but its true status has not been determined.

Indexing individual selected tubers by growing one piece from each tuber in advance of the field planting offers the most ideal method for eliminating virus diseases from the foundation seed stock. It is not practical, however, except under special conditions. The planting of the seed plot in tuber units is the most practical and effective method for developing and maintaining the potato seed stocks on the farm. It is possible but more difficult to control these diseases by careful roguing in mass-planted seed plots. Following very careful roguing in mass-planted plots we have succeeded in reducing the amount of rugose mosaic present in one lot of potatoes from year to year as follows: 1925, 4.5 percent; 1926, 2.8 percent; 1927, 1.7 percent; 1928, .4 percent. It is well to mention that this was accomplished under more careful roguing than is generally practised by commercial growers.

The results obtained point to the desirability of the wide-spread adoption of the seed plot plan for maintaining the potato seed stock with relative freedom from the virus diseases.

Bulb diseases. This project is cooperative with the Bureau of Plant Industry.

Narcissus Mosaic or grey disease is systematic and apparently infectious and it lowers quality and yield perceptibly. It can be eliminated by careful and persistent roguing. Too little attention is given to this matter at present.

The "breaking" of tulips, a condition known for at least 300 years, has been proved in our plots to be an infectious mosaic disease. This is the oldest virus disease of which there is an authentic record in literature. This disease has been successfully transferred from fifteen varieties of broken tulips, including four commercial Rembrandts and one or more representatives of the Cottage, Breeder, and Darwin types to a single tulip variety, Clara Butt; and from this variety to 17 other varieties, resulting in the production of a similar type of disease in all of them.

The disease was transferred by three methods of inoculation; namely, leaf mutilation which gave 30 percent infection; tissue graft, 33 percent, and aphid transfers, 12 percent infection. One species of aphid, *Macrosiphum solanifolii,* transmitted the disease to 24 percent of the plants exposed; other species, including *Myzus persicae* and *M. pelargonii,* gave relatively low percentages of transmission.

Spread in the field under natural conditions is often quite high. For example, one stock gave the following record: 5 percent affected one year, 17 percent the next, and 65 percent the third year.

Roguing proved to be quite effective in reducing the amount of disease under the conditions encountered. Apparently complete control may be obtained under careful and thorough methods. If aphids were abundant early this would result in less satisfactory control.

Tulip fire (*Botrytis tulipae*) is a fungous disease which often causes unsightly rotting and spotting of the foliages and flowers. It is both bulb- and soil-carried. Thorough cleaning of the bulbs before planting and crop rotations in which tulips do not occur twice in succession or oftener than once in three years on the same land are desirable as aids

in avoiding the disease. No treatment of the bulbs with fungicides or sprays on the foliage tried to date is sufficiently satisfactory to justify recommendations without further tests.

Mosaic of bulbous iris is now present in large amounts in some stocks of commercial iris and is causing very appreciable damage. It weakens the growth and results in slow increase and poor flowers. Affected plants give very poor results when forced. Roguing of the stock while growing in the field appears to be the chief method available for control. This is believed to be practicable and entirely feasible. The practice of this method is strongly urged on all growers.

"Curly-top" of various crops. This new project was started early in the biennium. The work proved that "curly-top" affected many of our cultivated crops besides beets including tomatoes, squash, beans, pepper, cantaloup, cucumber, horseradish, spinach, zinnia, and strawflower, and a number of weeds. This progress explained a condition which had previously been very baffling.

A systematic testing of commercial varieties for resistance to this disease was begun. This has resulted in the finding of some varieties of beans and squash apparently highly resistant to the disease and able to give good crops in a region where the disease is generally prevalent and severe. We know of no other control than resistance for avoiding loss from this disease.

Miscellaneous diseases. The leaf and stem nematode attracted considerable attention during the biennium. The State Board of Horticulture is undertaking to eradicate the clover-strawberry nematode population from the Willamette Valley. Cultivated teasels showed infection involving in some cases 80 percent of the plants. The loss was quite heavy. The parasite was readily seed-carried. In an effort to aid the grower to produce a teasel crop free from nematodes, the Station treated for field planting a large quantity of seed at 48° C. for 30 minutes. Alfalfa was seriously affected at Ashland and in Butter Creek, Umatilla county. In this latter location heavy damage is to be expected in the future. No new information was obtained on host range of different populations. Clover, alfalfa, and teasel are assumed to be affected by different populations.

Virus diseases of bramble fruits. This project has been discontinued. The chief findings during this biennium are reported under Publications (abstract of article on "Dwarf of Blackberries").

Perennial canker of apples. New infections have been linked up more definitely with frost injury for the most part affecting tissues made abnormal by woolly aphis. Low temperatures crack open the spongy tissues produced by woolly aphis infestations and infections take place through these cracks. It would seem then that control is largely an entomological problem coordinated with clean tree-surgical methods. The cleaned wounds should be protected by the use of suitable tree paint. Of those already tested out the superintendent of the Hood River Branch Station prefers the Hood River tree paint.

The cost involved and the inability of growers to carry out the tree-surgical program in badly infected orchards render present-known control measures rather impractical.

This project was discontinued as an Adams project when cooperation of the United States Department of Agriculture was obtained and the department sent a representative to Hood River to work on the problem in cooperation with the Hood River Branch Station. Some work on the life-history of the causal organism will be continued by Dr. S. M. Zeller.

Verticillium wilt of black raspberry. Considerable circumstantial evidence in many black raspberry plantings has led to the belief that this disease is one of the important factors limiting yields of this crop in Western Oregon. Field conditions would indicate that the Verticillium wilt of potato also infects black raspberry and that neither crop should directly follow the other. A project to learn the necessary rotation period to other crops before the soil is free from black raspberry wilt has been started. The land is becoming infected with both the potato and black raspberry organism.

The strain of Verticillium isolated from black raspberry is more virulent on black raspberry than that isolated from potato. We cannot as yet draw conclusions regarding relative susceptibility of the varieties tested.

Disinfection of fruit in connection with spray residue removal. Some thirty-five possible disinfectants have been tested for the control of decay of apples or pears. Of these (1) formaldehyde and (2) borax-boric acid were the most effective. Under laboratory conditions, controlled tests have proved formaldehyde to be a very effective preventive of blue mold decay when subjected to concentrations of 1 part in 150 or 200 parts of water for 5 to 6 minutes. Under practical conditions as the most effective and practical washing machines for spray residue are now operated the use of a disinfectant is not advised.

There are several reasons why disinfectants have not been effective under practical conditions. (1) Infection in many cases has already started before washing takes place. (2) The length of treatment necessary for spray residue removal and the strength of solutions permissible are insufficient to destroy such spores as may remain attached to fruit. The fact that disinfectants must be removed from the fruit as part of the washing process undoubtedly reduces their effectiveness. (3) While the spores that are washed off into the solution may in time be killed by disinfectants, viable spores are presented from the supply of fruit constantly coming in. (4) In some cases the chances for reinfection following washing treatment nullify the effects of disinfectants. On the other hand where very clean water is used in the atomizer or splasher type of machines there is less decay of fruit after washing than in the unwashed fruit. This is especially true in the case of perennial canker and anthracnose decay of apples. A report of our laboratory findings will be published later.

Strawberry root rot. The aim of this project is to learn the cause and possible control of a disease affecting strawberries in the hilly dis-

tricts on the western slopes of the Cascade Mountains and in the Willamette Valley. Plantings having from 1 to 100 percent of the plants infected have been found. The project has been under way a few months only.

DEPARTMENT OF ENTOMOLOGY

Investigations in this department were somewhat expanded during the biennium, as indicated by the amount and character of research briefly reported in the following pages.

The urgent calls for research and assistance in the control of insects were greater than in past years. Resolutions have been received requesting investigations to work out control methods for Syneta leaf-beetle, which is damaging cherries; strawberry crown-borer, which is becoming a limiting factor in strawberry production; and the prune thrip, which is becoming in some years a limiting factor in prune production. A beginning has been made on some of these problems, but the funds available for the department are by no means adequate to meet the needs for investigation. The following is a brief report by projects on the investigations conducted during the biennium.

Strawberry root-weevil project. This investigation was undertaken as a Purnell project in the spring of 1926. The studies comprise field and laboratory tests with home-made baits and with commercial baits; experiments relative to the time of application, manner of mixing and applying the home-made baits and studies of the life habits of the weevils. Results of first year's work are reported in Station Circular 79, The Strawberry Root-Weevils and Their Control in Oregon.

During the second year the experiments with apple baits to find out the most active poison and the best time and method of application of baits for the most effective results were continued. In addition, tests were made on materials which may be used as substitutes for apple. Some of these are particularly promising.

Besides the species mentioned as new in Station Circular 79, another new species, *Dyslobus decorata* Lec., has been found doing severe damage. The work on the strawberry root-weevils should be continued in order: (1) to check on the time and number of applications of apple and other baits for the three common species and also to make a comparison of apple baits with substitutes; and (2) to study the life habits of the two new species of weevils and initiate control tests directed against these weevils.

Oil spray codling-moth project.

Field tests were begun in 1926 in cooperation with the Oregon Apple Company, B. W. Johnson, Manager, at the Company orchards near Monroe. The sprays were applied with the company's regular crew and outfit, under the supervision of the Agricultural Experiment Station. During the season of 1926, Volck oil, a home-made emulsion of crystal oil, and one of cylinder oil were used. A 2-percent solution was used in each test. All of these gave serious injury to the fruit. Nothing but

cull apples were obtained from any of the plots. Worm control was but little better than the check.

During 1927 the following sprays were used:

(1) Sherwin-Williams Spray emulsion (1½ percent oil)

(2) Standard Oil oronite technical caseinate emulsion (1½ percent oil)

(3) Standard Oil mineral seal caseinate emulsion (1½ percent oil)

Wormy apples ranged from 18 to 25 percent while the lead arsenate check gave 4 percent wormy fruit. Ten trees were used in each test. More than 4,000 apples were examined from each plot and the number of wormy and stung apples tabulated.

Laboratory tests were tried as follows: A number of apples were placed in cages with codling-moth; 8 apples which had 40 or more eggs deposited on each were removed and divided into 4 lots; one lot was used as a check and one was sprayed with S. and W. free emulsion; one with the oronite technical oil; and one with mineral seal oil. On the check 90 percent of the eggs hatched; 2.3 percent of those sprayed with mineral seal hatched; 3.5 percent of those sprayed with oronite technical hatched; and 10.4 percent of those sprayed with the S. and W. free emulsion hatched. The tests were repeated with the following results: 100 percent of the eggs on the check hatched, while only 2.6 percent of those on the mineral-seal lot hatched; none on the oronite technical lot hatched, and 10 percent on the S. and W. free emulsion lot hatched.

A series of apples sprayed with each of the three oils were introduced into cages with codling-moths at intervals of 48 hours after spraying and eggs obtained. It was found that eggs deposited on sprayed fruit four days after spraying hatched as readily as those on unsprayed fruit.

Where unsprayed apples were introduced along with the sprayed fruit, the codling-moth showed a preference for the unsprayed apples, depositing but few on the sprayed apples.

The project should be continued using a combination of oil and nicotine, oil and lead arsenate, and oil followed with lead arsenate. The 1927 tests indicate that oil has value as an ovicide but that where used throughout the season in sufficient quantity to control moth, serious injury to the fruit is likely to result.

Importation and establishment of Tachinid fly parasites on the European earwig. This project, undertaken in 1924 with the city of Portland, the State Board of Horticulture, the Oregon Agricultural Experiment Station, and the Bureau of Entomology, U. S. Department of Agriculture cooperating, is making progress. The work is under the direction of Mr. H. C. Atwell, Earwig Commissioner, with Mr. H. C. Stearns, Parasitologist, in charge. The entomologist of the Experiment Station is acting in an advisory capacity.

The importations from Europe of the two species were continued; 648 pupariae of *Digonochaeta setipennis* were received in 1926. To this material

may be added 109 puparia reared at Portland from material shipped in 1925, making a total of 757 puparia. Of this total only 467 puparia yielded living flies. During the season 189 gravid females were liberated, two of these liberations being made in different parts of Portland under natural conditions of earwig infestation.

Onion maggot (*Hylemyia antiqua* Meigen). Control studies on the Onion Maggot were continued in the 1926 and 1927 seasons.

In 1926 the experiments were conducted on three plantings in the Lake Labish district and in 1927 in two plantings in the Lake Labish district. Tests were made with trap crops, dusts, sprays, repellents, ovicides, and with traps for the fly.

None of the methods tried gave perfect control for this insect, but progress was made in the work. It was found that trap crops and fly traps aided in that a large number of flies and maggots could be destroyed in this manner. No appreciable reduction of the injury, however, could be noticed when these methods were used. Corrosive sublimate, 1-1000, applied to the plants every week for five weeks, beginning when the plants were 1 inch high, gave a very satisfactory increase in yield in the 1927 season. This is a rather expensive treatment and unless the grower knew that the maggots were going to be severe, it would not pay for the cost of application.

Funds should be available not only to continue the work with ovicides and fly traps which have given the most promise, but to make an intensive study of the habits of the fly to find out why in one year the flies attack only a certain portion of the field and in another year another portion. If it could be predicted where the flies were going to attack the onions, it would then be necessary to apply control measures to that area only. Equipment should be available to try out the pressure sprays that have been reported so effective in the Middle West and East.

Gooseberry borer (*Xylocrius agassizi* Lec.). Life-history and control studies on the black gooseberry borer were continued in the 1926 and 1927 seasons. This insect has proved to be a serious pest of gooseberry plants in the Willamette Valley. Entire gooseberry plantings are destroyed in but a very short time.

The observations on this insect have been confined to one planting in the Salem district because of lack of time and funds for this work.

Progress has been made in the study of the life-history and habits of the insect, so that the general life-history of the pest is now pretty well known. Control tests were initiated against the eggs of the beetle in 1926 but proved ineffective. In 1927 experiments were made with paradichlorobenzene, carbon bisulfide, and calcium cyanide as fumigants against the larvae. An application of one ounce of paradichlorobenzene per plant in August gave promising results.

A more thorough study of the life-history of the beetle with especial reference to the adult stage is needed. The time of emergence of the adults varies greatly with the different seasons. The length of life and habits of the adults are but little understood. Further control

studies should be made to verify the results of previous years and to try new materials.

Bulb insects. Studies on the life-history and control of the Narcissus bulb flies were continued in the 1926 and 1927 seasons. The work in the 1926 season was made in two bulb plantings in the Salem district and a survey was also made of most of the bulb plantings in the state. In 1927 the work was continued on a planting in the Canby district and at Corvallis.

The results of this work have been published from time to time and can be found in the following publications:

Journal of Economic Entomology—October 1926
Journal of Economic Entomology—October 1927
Florists Exchange—October 1926
Oregon State Board of Horticulture—1927
Eighteenth report Horticultural Society

Control tests were especially initiated against the eggs of the flies in the field and good progress has been made with this work in the control of both flies. An effective control measure against the Greater Bulb Fly is especially necessary now as the Lesser Bulb Fly is kept in check by the present method of handling by the growers, including mainly the hot-water treatment.

Experiments should be continued especially in the control of the Greater Bulb Fly in the field and to determine the effects of the various materials on the growth of the bulb, flowers, and leaf growth, both in the field and in the greenhouse under forcing conditions.

Syneta leaf-beetle (*Syneta albida* Lec.). Experiments for the control of the Syneta leaf-beetle on cherries in the Willamette Valley were continued in the 1926 and 1927 seasons. In the 1925 season, Syneta caused serious injury to the cherries in the Salem district for the first time in several years, and in the 1926 season the injury was still severe causing as high as 70 percent injury to the fruit in some orchards. An urgent request was made in 1926 by the cherry growers of Marion and Polk counties to do extensive work on the control of this insect.

The 1926 experiments were conducted in two orchards in the Salem district and in the College orchard at Corvallis. In 1927 the experiments were conducted in four orchards in the Salem district in different locations. Tests were made with both liquid and dust spray materials in various proportions and at various times of application.

Results show that the percent of injury to the fruit could be reduced about 70 percent by the application of several dusts and sprays. The time and number of applications varies with seasons, but on the average an application just before blossoming and just as the petals fall is the most effective. A spray of lead arsenate, 4-100, has proved as effective as any of the materials tried when the trees are thoroughly sprayed.

The work should be continued so that the relation of the time of emergence of the beetles to the stage of development of the cherry crop, and the relation of the abundance of the beetle to weather conditions,

could be predicted. Serious injury occurred in 1926 while the following year the Syneta was much less abundant and did but slight damage. Further trials should be made with spray materials in an effort to save the other 30 percent of the injured fruit that the sprays now in use will not handle.

Prune thrips (*Taeniothrips inconsequens* Uzel). Experiments for the control of prune thrips were begun in the spring of 1926, to determine how important a factor prune thrips were in the production of prunes in the state, and if found to be a limiting factor, to work out suitable control measures. The scope of the project was limited to observations and experiments in one orchard in the Shaw district because of lack of funds. The project was on a cooperative basis with the Salem Chamber of Commerce and the Oregon Agricultural Experiment Station, and was run for three seasons, beginning with 1926 and continuing to 1928. The necessary funds for the spray materials and other equipment were furnished by the Salem Chamber of Commerce.

The results of the first two seasons work have shown that in some years the prune thrips are a serious limiting factor in the production of prunes. This was especially noticeable in the 1927 season. The results also show that the application of suitable spray materials early in the season will control the thrips to a certain extent and insure an average set of fruit. The exact details as to what is the best spray to use, and the time and number of applications necessary, will be worked out by additional experiments.

This work should be continued for at least three more years so that the relation of the weather and the thrips to the setting of the fruit can be better understood. Funds should be available so that the work also can be carried on in more than one of the important prune producing sections, as the work done in one section might not be applicable to the other sections.

Apple aphids. The control tests against the rosy apple aphis were continued. The tests were conducted in cooperation with the Oregon Apple Company. Due to the fact that very few aphids were found in either the spray or check plots in both 1926 and 1927, no conclusive results as to the value of the sprays were obtained. The individual factors which affect the increase and abundance of the apple aphids are little understood. There is need for study of the relation of climate, ladybird beetles, and other parasites on the abundance of these pests. Such a study would enable us to identify the principal forces responsible for the abundance of the pests and possibly to advise whether to spray. A saving of one season's spraying cost would more than pay for the cost of this investigation.

CODLING-MOTH STUDIES

This project was continued during the biennium for the purpose of obtaining accurate life-history data in order that the codling-moth sprays might be properly timed. The cover sprays are timed to follow the peaks of egg deposition. These spray dates can be determined only by

following closely the activity of the moths. The project consisted of weekly observations of the insect in the field. Bait traps consisting of glass jars filled with fermented apple juice were also operated from the time the moths emerged until their activities ceased. In this way the abundance of moths active in the field was established for each day. The 8 p.m. temperature was recorded for each day. During the late winter and early spring 100 larvae were examined each week.

The date on which the first larvae pupated was established, as was the date on which moths first appeared in the field. The activity of the moths was followed throughout the season and the proper date for each spray determined. This information enables the Station to give the apple and pear growers and county agents the dates for codling-moth sprays. Where these recommendations were followed, satisfactory control of the codling-moth resulted.

There are marked variations, from generation to generation and season to season, in the response of this insect to its environment.

Substitutes for lead arsenate. This project was started during the season of 1927 because of the recent restrictions placed on the sale of foods containing arsenic, and the difficulties and expense involved in removing the residue from apples when sprayed with lead arsenate. There was considerable demand from the apple and pear growers of the state for a non-arsenical substitute for this spray.

The experiments were conducted at the Oregon Apple Company orchards, B. W. Johnson, Manager, cooperating. The sprays were applied with a big bean sprayer, the regular Oaco crew operating it under the supervision of the Station. Ten trees, two varieties (Newtowns and Ortleys) were used in each test. More than 12,000 apples were examined on these plots and the number of worms and stings recorded.

The following materials were tried out:

No. 1. Manganar, 2 pounds to 100 gallons water
No. 2. Calcium fluosilicate dust (15 percent)
No. 3. Sodium fluosilicate dust (15 percent)
No. 4. Calcium arsenate, 2 pounds to 100 gallons water
No. 5. Lead arsenate followed with the last cover spray of Black-Leaf-40
No. 6. Lead arsenate check
No. 7. Unsprayed check

The dusts were applied with an American Beauty hand duster. The regular spray calendar was followed. The calcium arsenate and manganar gave as good control as the lead arsenate, while the fluosilicates gave practically no control. Where Black-Leaf-40 was substituted for the lead arsenate in the last cover spray, the number of clean apples was reduced slightly. The tests are being repeated this year with the addition of several other materials. Results indicate that there is a possibility of obtaining a satisfactory substitute for lead arsenate.

Comparison of varying strength of lead arsenate with and without spreader in codling-moth control. This project was continued during

the biennium in order (1) to determine the value of calcium caseinate spreader in lead arsenate sprays in the control of codling-moth; (2) to determine the effect of increased dosages on moth control; (3) to determine the effect of a shortened spray schedule on codling-moth control.

The following sprays were used with the results noted:

	Amount of lead arsenate used	*Clean*	*Wormy*	*Stings*
		%	%	%
1.	2 pounds to 100	85.1	4.6	10.3
2.	2 pounds to 100 plus spreader	90.8	2.0	7.2
3.	4 pounds to 100	95.1	1.2	3.7
4.	4 pounds to 100 less last cover	94.7	1.7	3.6
5.	4 pounds to 100 plus spreader	95.6	0.7	3.7
6.	4 pounds to 100 plus spreader less last cover	90.9	2.1	7.0
7.	6 pounds to 100	91.3	1.6	7.1
8.	6 pounds to 100 less last cover	91.1	1.6	7.3
9.	6 pounds to 100 plus spreader	91.2	1.6	7.3
10.	Same as No. 9 less last cover	91.2	1.4	7.4
11.	Check	8.0	87.0	5.0

Results indicate a slight increase in control where spreader was used and a decrease where the last cover spray was omitted. Increasing the dosage up to 4 pounds to 100 gallons gave a higher percentage of clean apples.

Dust spraying versus liquid spraying for codling-moth control. This project was started in 1927 in cooperation with the Oregon Apple Company. Due to the spray residue problem and the fact that certain orchards in the state are situated far from water and on steep hills so that spraying is not practicable, there has been considerable demand for information on the value of dust as a control for codling-moth.

During the 1927 season about 700 acres of the Oaco orchard were dusted with lead arsenate dust and about 100 acres with calcium arsenate dust. The dust was applied with a new Niagara power duster by the regular Oaco crew and results checked by the Station.

The plots dusted with lead arsenate dust, 80-20 sulfur-lead-arsenate mixture (20 percent lead arsenate) yielded 85 percent clean fruit, 5 percent wormy fruit, and 10 percent stings. The plots dusted with calcium arsenate dust yielded 86 percent clean fruit, 7 percent worms, and 7 percent stings, with no apparent injury. Unsprayed check yielded 8 percent clean apples and 92 percent worms and stings. The lead-arsenate plots yielded 88 percent clean apples. More than 5,000 apples were examined from each plot and the wormy fruit, clean fruit, and stung apples were counted.

Results indicate that under favorable weather conditions dusting might prove as satisfactory for moth control as spraying.

Tests should be continued for at least three more years in order that the effect of varying seasonal conditions on dusting might be ascertained. The 1927 season was favorable to dusting in the Willamette Valley,

since there was so little wind that the dusting operations could usually be continued from 12:00 o'clock midnight to nearly noon.

Peach and prune root-borer control project. This project was practically suspended during the biennium. No evidence has been accumulated to indicate that paradichlorobenzene, when properly applied, will injure young trees in Oregon. Late in the fall of 1925 and during 1926, an investigation was made of an infestation of the prune root-borer in a cherry orchard. As many as twenty larvae were taken from one tree and every tree examined was found to be infested. Forty trees had already been killed by this insect and many others were in a dying condition. Twenty acres of twelve-year-old cherry trees in another part of the orchard were also heavily infested.

The studies revealed that the worms attacked only the *Prunus mahalab* root stocks. Seedling cherry trees and cherry trees on seedling cherry root stock were found to be entirely free from borers, although some of these trees were immediately adjacent to the heavily infested orchard. A report of these studies is to be found in Journal of Economic Entomology Vol. 19, Page 799.

Study of symphilids, their life-history and possible methods of control (*Scutigerella immaculata* Newport). This project was continued during the biennium. Complaints of damage by this centipede are increasing each year. Control tests were carried on in cooperation with Herbert and Fleishauer at their aster farm near McMinnville. The following were tried as possible control materials:

1. Poison corn bait (corn soaked in bichloride of mercury, 1 pound to 600 gallons for 48 hours)
2. Calcium cyanide (flakes)
3. Paradichlorobenzene
4. Crude naphthalene
5. Carbon bisulphide emulsion
6. Lime
7. Check

Results:

No. 1. In this plot a few dead symphilids could be found. There appeared to be fewer live ones than on the check plot for several weeks after planting the corn. Most of the corn was eaten by the symphilids.

No. 2. Applied on the surface of the soil at the rate of ½ pound to 1,000 square feet, and spaded under. Gave practically no control.

No. 3. Applied as was No. 2. Seemed to have a repelling effect and apparently killed a few symphilids.

No. 4. Applied same as No. 2. Gave no control.

No. 5. Carbon bisulfide emulsion (emulsion diluted and applied with a garden sprinkling can) acted as a repellent for a short time.

No. 6. Lime was applied on four plots of 100 square feet each at the rate of 2, 4, 6, and 8 tons per acre, respectively.

Throughout the season there were as many symphilids present on all the lime plots as on the check plot.

A study of the life-history of the symphilid was made in the field. Eggs were brought into the laboratory and the development of the young nymphs studied.

The first eggs were found in the field on April 22. The first young symphilids were observed May 2. Eggs were present in the soil until June 2. The young symphilids all appeared to be full-grown by August 1. Eggs are small, pearl-like, and are laid in clusters of ten to twenty. The average length of the egg stage was twenty days.

Some overwintering symphilids brought into the laboratory on May 16 lived until September 1.

The project should be continued since reports of injury from this pest are increasing from year to year and indicate that this centipede is becoming a garden pest of major importance. The life-history should be thoroughly worked out and all possible means of control tested.

DEPARTMENT OF AGRICULTURAL ENGINEERING

The experimental work in Agricultural Engineering was continued throughout the biennium. The major investigations were those made possible by the Oregon Committee on Relation of Electricity to Agriculture. Excellent progress was made on the program of investigations sponsored and financed by this committee. The following is a brief statement by projects undertaken.

Electric lights for increasing egg production. This project has been in progress for three years past in cooperation with the department of Poultry Husbandry. Two flocks of pullets and one flock of yearling hens were included in the tests each year. One half of each of these flocks was lighted with Mazda lamps and the other half was not lighted. Approximately 800 fowls were included in each year's tests. Results have been published in Station Bulletin 231, Electric Lights for Increasing Egg Production, which is reviewed under Publications.

Electric water heaters for poultry. During the years 1926 and 1927 tests were made on various types of electric heaters for use in warming poultry drinking water. These heaters were given a practical test in the poultry houses during the winter of 1926-27. The results of the investigation prepared cooperatively with the Poultry department are presented in Station Circular 81, Electric Water Heaters for Poultry.

Prune dehydration. Studies of prune dehydrators started in the fall of 1925 were continued during the 1926 drying season. These studies were conducted cooperatively by the Oregon Committee on Relation of Electricity to Agriculture and the Horticultural Products section.

The studies indicated that the use of electric fans for recirculating the air in prune driers increased the capacity of the plant, made the production of a better product possible, and enabled the operators to have more certain control of the process of drying. It was found that adding

a motor-driven fan to the Oregon tunnel type of drier produced results approximately equal to the more costly driers of newer type which were being constructed. One of the outstanding results of the investigation was the discovery that prunes dry more rapidly at high initial temperatures and low finishing temperatures, and with low relative humidity at the beginning of the process and high relative humidity at the end of the drying period. These conditions are the reverse of those existing in the present type of driers. Further work will be needed to prove the practicability of changing the drying system from that now in use.

Refrigerators for general farm storage. Investigations were conducted during 1927 to determine the possible products which might be stored in a refrigerator on the general farm for the purpose of designing a refrigerator of large capacity which might be sold at a more reasonable price than those now available. After determining the products to be refrigerated a box having approximately 40 cubic feet of food storage capacity was designed. One of these boxes has been constructed and additional boxes will be built. The studies will include convenience in using the boxes, the cost of operation, and the economic value of such boxes for farm use.

Arc lamps for lighting poultry houses. This project was started in 1927 in cooperation with the Poultry department. The investigation consisted first in obtaining a suitable arc lamp and selecting carbons which would give a steady light rich in ultra-violet radiation. An ordinary street-lighting multiple-arc lamp supplied with the National Carbon Company's Therapeutic B carbons was finally selected for the test. One pen of 100 White Leghorn pullets was lighted with the arc lamp and a pen containing an equal number was lighted with Mazda lamps. The mortality in the Mazda-lamp pen was 26.6 percent in five months, and in the arc pen 10.4 percent. The Mazda-lamp fowls made a gain of 12.1 percent in total weight and the arc fowls 23 percent. The difference in production between the two pens was 6.7 percent, the arc lighted fowls producing the smaller number of eggs. The average production of the two flocks during the five-month period was approximately 60 percent. Tests were made on the breaking strength of the egg-shells produced by the different pens and, while the results are not conclusive, they indicate that the egg-shells produced by the arc-lighted birds were the stronger.

Cheese starter incubators. In cooperation with the Dairy Husbandry department, a simple thermostatically controlled electric heating element was devised for holding the temperature of cheese starter at a constant point. The device has enabled cheese factories to produce a better grade of starter, and to be more certain of the product. The incubators have been installed in many of the cheese factories in the Tillamook district.

Dairy water heaters and sterilizers. Field studies were made on the use of electric sterilizers for dairy utensils and of different methods of heating water electrically for use in the milk house. It was found that electric dairy sterilizers now on the market were satisfactory for sterilizing utensils, but were not satisfactory for heating water because of the inconvenience of the system, and the difficulty in keeping the equipment

clean. Various arrangements of electric hot-water heating equipment have been tested out in order to find some arrangement which would not be excessive in cost and would eliminate the extra labor and fire hazard of heating water with wood or oil. An 18-gallon tank equipped with a 600-watt heater controlled by a time switch is proving reasonably satisfactory, but further investigation is desirable.

Brooding chicks. Comparative studies of brooding chicks by electricity and other means have been continued during the biennium. A three-year test has now been completed. The results have not all been summarized, but in general the electric brooders have proved to be satisfactory from the standpoint of the quality of chicks produced and the cost of operation. The labor of caring for the electric brooders was considerably less than for other types.

Feed grinders. The studies of different types of feed grinders have been continued during the past two years. The conclusions have been that the small hammer-type of mill is probably most satisfactory for general farm grinding with an electric motor. Very satisfactory grinding has been done, however, with the burr mill and a test is now under way in steaming and milling grain with a small, motor-driven roller-mill. This project has been carried on in cooperation with the department of Animal Husbandry.

Hay hoisting. Work on the development of a satisfactory farm hoist has been continued during 1927-28 in cooperation with the Animal Husbandry department. A single drum hoist has been decided upon as most feasible and most economical for farm use. Two hoists of this type have been designed and built for putting hay into the barn. The man on the load does all of the hoisting and pulling back of the fork without assistance. This saves the use of one or two horses and a man or boy on the haying crew. The farm hands like the arrangement better than the old system of pulling up hay with horses because the man on the load has control of the operation at all times.

Other investigations. Work has been in progress during the past year on the development of a small motor-driven green-feed and straw cutter for poultry farm use. Three of these cutters of different styles are now being used with very satisfactory results.

Field studies of irrigation costs and returns in the Willamette Valley, the operation of various types of electric refrigerators in the dairy, the operation of motor-driven cream separators, grain elevators, gooseberry cleaners, and hay choppers have been made.

DEPARTMENT OF HOME ECONOMICS

Agricultural Experiment Station work in Home Economics was begun in December, 1925, with Purnell funds. Study has been concentrated on one project.

Present use of time by farm homemakers. This Home Management project was undertaken December 1, 1925. Oregon is one of several

states in which the study is being carried on in cooperation with the Bureau of Home Economics of the United States Department of Agriculture, and the results of the study in Oregon will be comparable with those now under way in the other states.

Detailed and complete records, each for seven days, have been received from 520 representative homemakers of the state. Twenty-seven of these kept records for a second week, making 547 records available for study. Three hundred and eighty-three of these records are from country homes and the remainder from homes not in the country but with otherwise comparable conditions. The data on these records have been classified and summarized and the work of analysis and interpretation is well under way.

Further work on this study may take three forms: (1) The obtaining of more records where the number now on hand is insufficient to show the effect of a significant factor; for example, the Relation of Time Distribution to the Character of the Farm Enterprise. (2) A study of the time devoted by farm homemakers to the major seasonal or occasional tasks of sufficient magnitude to disturb household routine, such as house cleaning, harvest, holiday seasons, etc. (3) Studies in the field of housekeeping technique which will contribute to the objects of the Time Study. For example, The Time-Saving Value of Certain Articles of Household Equipment.

The study is intended to show the amount of time spent by homemakers on their various homemaking activities, and the amount of help received. It will bring out the influence on time spent in homemaking activities by such factors as (1) the size and composition of the family, (2) equipment and housing, (3) the use of laundries, bakeries, and other outside agencies, (4) the locality, and (5) the season of the year. It will show to what extent time spent in homemaking activities seems to depend on the size of the job rather than on standards of homemaking and individual efficiency. It will also bring out the relation between the amount and nature of the homemaker's tasks and the manner in which she uses her leisure and other personal time. The extent of the need for reducing the homemaker's work-day will be noted, as well as possibilities for reducing by various methods the time spent in homemaking.

It is expected that the results of the study will show the extent and nature of the farm housekeeper's time problems, and to point the way to subsequent studies having as their object the solution of these problems.

The results of the study will constitute a contribution to Home Economics subject-matter of value not only to Home Economics teachers, but also to individual homemakers who are interested in analyzing their own jobs with a view to more efficient time utilization.

RESULTS OF THE INVESTIGATIONS OF THE BRANCH EXPERIMENT STATIONS

AT THE branch experiment stations at Astoria, Burns, Hermiston, Hood River, Moro, Talent, and Union investigations were continued along the lines of the previous biennium. The work of each station has been centered as in previous years primarily on the

major agricultural problems of the respective agricultural section represented by the branch station. In addition the branch stations have cooperated with the Home Station at Corvallis in a few investigations for solution of problems common to larger sections of the state or the state as a whole. The character of work and the results are stated briefly in the following pages.

JOHN JACOB ASTOR BRANCH STATION, ASTORIA

The Astoria Branch Station continued the previous program involving primarily a study of problems pertaining to dairy production, forage crops for dairying, soil fertility, drainage, and land clearing. In a program of this nature, progress is mainly a matter of gradual development. There are few outstanding accomplishments which may be attributed to the work of a single year or two-year period.

The Astoria Station during the comparatively short period of existence has accomplished a great deal for agriculture in the Coast Region of Oregon. Accomplishments which are publicly recognized and acknowledged of value include the following:

(1) Worked out the basis for maintaining the permanent fertility of the soils of this section.

(2) Developed a complete soiling crop system whereby it is possible to have plenty of succulence in dairy feed for the entire year.

(3) Demonstrated the effects of the feeding of soiling crops in increasing the summer dairy production in this section.

(4) Discovered the means of root-maggot control through late planting of susceptible crops.

(5) Discovered the reason for the failure of clover crops and devised the remedy.

(6) Worked out the reasons for the failures in vetch growing, and developed the remedy.

(7) Found and proved the necessity of supplementing manure with superphosphate in the growing of the root crop.

(8) Introduced into the Oregon Coast Section with excellent results the following crops: Japanese barnyard millet, Ladino clover, Hungarian vetch, Austrian winter pea, Pomeranian White Globe turnip, Imperial Green Globe turnip, Monarch and Up-to-Date rutabagas, Prize-winner and Sludstrup mangels.

(9) Devised a system of tile drainage for tide-lands and demonstrated its effectiveness.

(10) Worked out balanced grain rations adapted to winter feeding with this section's home-grown forage crops.

During the biennium ending June 30, 1928, the dairy herd has been much improved in quality of livestock and production. This herd, with the management and feeding data accumulated for local conditions, has had a marked influence on the dairy industry of this section of the state.

One major accomplishment of the Station is the introduction of new legumes, and definitely establishing profitable production of legumes. When the Station was established, clover could be grown for a year or two on new land. No other legumes were grown. The outstanding development of the biennium was the introduction and apparent possibilities of the Austrian winter pea. This crop has real promise for the Coast section.

The two years' additional data have strengthened the position of the Station and its recommendations as to crops, varieties, fertilizers, time of planting, herd management, and other problems of importance in developing and maintaining dairy farms of the section. In keeping with this growing strength, the number of farmers and business men who visit the Station has greatly increased. For example, approximately 50 persons from Columbia county and 200 from Tillamook county visited the Station on June 23, 1928. On July 1 approximately 250 persons from Clatsop county visited the Station. Much of the superintendent's time is taken in giving out information to visitors and at farm meetings on request.

The superintendent of the Station is still called on to take an active part in the marketing activities of the Lower Columbia River Dairy Association. This service is not research in nature, but the purpose of the Branch Station is to assist proper development of agriculture in that section of the state. Proper development must center in the immediate future, at least, on dairying and poultry production. At the present time, however, assistance can not be better rendered than in connection with the marketing of dairy and poultry products.

HARNEY VALLEY BRANCH STATION, BURNS

Investigations with cereals, forage, and root crops on dry and irrigated land are being continued. The dry-land investigations have been materially reduced with a corresponding increase in irrigation investigations.

New project started. The north eighty of the Experiment Station was selected as the location for a new demonstration farm unit under irrigation pumping. A well eighteen inches in diameter and eighty-five feet deep was drilled during December, 1926, to supply the water for irrigation. A turbine pump and a 25-horse-power semi-diesel engine were installed.

The purpose of this experiment is to obtain data on the cost of producing the leading farm crops with pumped water. This is an important project and was undertaken with a special state appropriation for the biennium granted at the urgent request of a number of leading farmers of Harney Valley. There are thousands of acres of good land in Harney Valley for which there will not be gravity water. The only method of reclamation for this land is by pumping.

Additional data obtained. Additional data are being obtained on all main lines under investigation but most of the projects have not been carried for a sufficient length of time to justify definite conclusions. The

statements following indicate the facts of value to practical farming to date.

Varietal trials—dry land. Results obtained at this Station indicate that the best varieties for dry land are Baart and Hard Federation wheat, Hannchen barley, Sixty-day and Silvermine oats, Vern spring rye, and Grimm alfalfa.

Varieties for irrigation. The following crops continue to be the leading varieties under irrigation: Federation spring wheat, Turkey or Washington Hybrid 128 winter wheat, Trebi and Hannchen barleys, Markton and Three Grain oats, Grimm alfalfa, Kaiser field peas, Mammoth Russian sunflowers, and Early Ohio potatoes.

Rotation experiments. Field peas in the short rotation and alfalfa in the long rotation are the leading legumes. The field pea inoculates easily, breaks down readily, and is much easier to incorporate with the soil than is alfalfa. It takes about three years thoroughly to subdue a good stand of alfalfa in this section.

Fertilizer experiments. Experiments with fertilizers started in 1919 with the major crops were continued through 1927. Manure and manure with superphosphate seem to give increased yields but results do not warrant any definite statement at this time.

Duty-of-water experiments. Duty of water is important in any section where water is the limiting factor for crop production. This is especially true in Harney Valley. Results indicate that the following amounts are reasonably correct for the production of profitable crops in Harney Valley: cereals, 12 to 14 acre-inches; alfalfa, 18 acre-inches; clovers and field peas, 15 to 18 acre-inches; Mammoth Russian sunflowers, 30 acre-inches; potatoes, 10 to 14 acre-inches. The results are not final and the amount applied will probably be increased in some cases.

Cost-of-production experiments. The cost-of-production experiments started in 1926 and 1927 are important and will be carried over a period of years. Results obtained to date under adverse conditions are encouraging and indicate possibilities of producing crops profitably in Harney Valley with pumped water.

The crops under consideration are Federation wheat, Kaiser field peas, Grimm alfalfa, and Early Ohio potatoes. The peas, wheat, and potatoes are being handled in a three-year rotation, and under field conditions.

Station accomplishments. The Harney Valley Branch Station since its beginning has been directly responsible for the following:

(1) The introduction and distribution of Grimm alfalfa in Harney and part of the surrounding counties. This Station has produced and distributed 5,000 pounds of Grimm alfalfa seed.

(2) The introduction and distribution of Baart, Federation, and Hard Federation spring wheat in Harney and part of the surrounding

counties. These varieties have practically replaced all other varieties grown, with the result that the yields have been increased five to fifteen bushels per acre. Formerly Little Club and Bluestem were grown, both of which were late-maturing, being often injured by late frosts. The introduction of Baart, Federation, and Hard Federation has practically eliminated loss by frost damage.

(3) The demonstration of the value of Federation wheat as an outstanding producer under irrigation.

(4) The introduction and distribution of Trebi barley, which is rapidly replacing the "Coast" variety. The Trebi matures earlier and outyields the "Coast" variety by 5 to 10 bushels per acre.

(5) Introduction of the copper carbonate treatment of wheat in Harney county. By its active work in bringing this method before the public the Station has practically eliminated smutty wheat from the county.

(6) The encouragement of the use of legume inoculation and assisting growers in obtaining the pure culture. The Station has aided in obtaining better stands and higher yields of alfalfa and field peas.

(7) Holding annual field days. The field days held each year are well attended and instructive, and they improve the community spirit.

(8) Rendering practical agricultural advice. The Station yearly answers hundreds of letters and telephone calls; whenever possible, personal visits are made on request.

UMATILLA BRANCH STATION, HERMISTON

The Umatilla Branch Station is jointly maintained by the Oregon Agricultural Experiment Station and the United States Department of Agriculture for the purpose of investigating problems related to establishing and maintaining permanent agriculture on sandy soils under irrigation. The investigations at the Station have been adjusted during the biennium to accomplish more on outstanding problems with the limited land and facilities available. A brief report on the investigations undertaken follows.

Reestablishing alfalfa. An outstanding problem which has received attention under this program is that of methods of rehabilitating the alfalfa lands of the Umatilla project which on account of winter-killing, weed encroachment, and continuous cropping are not giving the yields they formerly did. Two old fields of alfalfa have been plowed up; parts of the fields have been reseeded to alfalfa immediately while in the case of others reseeding to alfalfa is being delayed for one, two, and three years. The crops grown in the meantime include potatoes and corn as cultivated crops, and wheat and barley. Present information indicates that applications of barnyard manure and freedom from weeds have given promising results in reestablishing the alfalfa.

"Curly-top" investigations. The "curly-top" disease of tomatoes, beans, and squash, in particular, has caused serious losses to local farmers for years. Recent discoveries by the Central Station have opened the

way to testing varieties for resistance to the disease. This year (1928) 201 varieties of these crops and others either known or suspected of being susceptible are being tested at the Umatilla Station in cooperation with plant pathologists of the Home Station.

Sweet clover. Some difficulty has been experienced locally in obtaining stands of sweet clover for pastures. Results in 1927 showed very definitely that early seeding in late February or early March and rolling to obtain a firm seed-bed were sufficient to obtain satisfactory stands.

Time of cutting alfalfa. Results from the time-of-cutting experiments with alfalfa prove conclusively that the more mature the crop is allowed to become the higher the yield obtained from the land in a year. The quality of hay beyond rather full blossom, however, is questioned. After three years' trial no appreciable difference in the stands has been noted.

Lamb feeding. Nine tests of long, cut, and ground alfalfa hay over a period of three years indicate that cutting and grinding hay when supplemented with one pound of whole barley per head per day is profitable in fattening lambs for the late winter market.

Carrying the lambs on alfalfa pasture for a period in the fall has been found a practical and profitable method of holding lambs for the higher late-winter markets. The lambs do not make material gains while on the pasture but go into the feed lots in excellent condition for feeding.

Methods of irrigation. The methods-of-irrigation experiments which have been carried during a period of twelve years are gradually being discontinued as the land is needed for other purposes in the reorganization program. These results show the border method with large heads of water to be the most economical for the irrigation of light sandy soils growing alfalfa.

Value of manure. Barnyard manure applied to plots of alfalfa at the rate of 48 and 192 tons per acre during 6 years of the past 13 continues to increase the yields over plots not receiving manure. The lighter application has given much larger returns per ton of manure than the heavier one.

Water-holding capacity of sandy soils. Lysimeter investigations are being continued to ascertain whether cropping sandy soils with alfalfa and vetch and soy-beans tends to build up the water-holding capacity.

HOOD RIVER BRANCH STATION, HOOD RIVER

Perennial canker investigations. Following the isolation and naming of the perennial canker organism (*Gleosporium perennans* Zeller and Childs) in 1925, experimental work was started to determine in what manner infection takes place on the trees. A preliminary study of possible control measures was started. The investigation has shown that there exists a definite relationship of the woolly aphis to perennial canker infection; further, that to a large extent temperatures sufficiently cold

to freeze and rupture the aphis galls are necessary to permit the entrance of the disease. Approximately 90 percent of canker calluses kept visibly free from woolly aphis infestation failed to develop infection during severe winters. On the other hand, approximately 90 percent of the canker calluses on the same trees, allowed to become aphis-infested at some period during the summer, later became infected with the disease. During mild winters only traces of infection occurred on the aphis-infested calluses. All sprays tested to date have proved of no effect. Numerous paints have been tested following the cutting out of all diseased parts. All paints that dry and lift are worse than nothing in that the resulting protection offered the aphis increases the chances of infection. Only paints that persist tightly to the growing calluses are of value. Where paints of this character have been used, thus preventing aphis infestation, no further advance of the disease has occurred. Summer applications of bordeaux mixture have been found of value in reducing the extent of storage rot (Bull's eye spot) caused by this disease.

Apple scab control tests. Limited tests have been continued from year to year testing various combinations in the spray schedule for the purpose of finding a safer spray than lime-sulfur. Scab infection has been of such limited extent that conclusive data relative to control have not been obtained. Bordeaux-oil mixture in the delayed dormant spray followed by dry-mix lime and sulfur offers definite possibilities in the schedule for Hood River orchards.

Codling-moth control—arsenical residue. The arsenical residue problem has made it necessary to continue the study of control of the codling-moth. Seasonal behaviors of the insect are watched and growers are supplied with needed information for their control work. Numerous combinations of spray are under observation, including arsenate of lead at different strengths alone and in combination with various oils, nicotine and pyrethrum, also nicotine alone and nicotine-oil combinations.

Summer oil sprays have not been recommended owing to the possibility of injury to fruit, particularly in the Newtown variety. Some of the lighter oils seem to offer promise. In the Mosier district, where the residue problem appears to be most difficult, on account of orchard dust being associated with the spray, a large number of combinations are under observation, the arsenate of lead being associated with lime at different strengths used at different periods. The use of lime offers promise in the arsenic removal on account of its favorable reaction with the acid wash. A study of the residue problem in all the combinations under observation is being made in cooperation with the departments of Chemistry and Horticulture of the Home Station.

Strawberry root-weevil control. Work has continued during the biennium in cooperation with the department of Entomology. All methods of weevil control other than baiting for the adults have proved ineffective. Baiting for the overwintering adults, which appears to be of minor importance in Western Oregon, has been found to be most important in the Hood River section. Overwintering weevils have been found to deposit fertile eggs in large numbers throughout the summer. The apple bait made up with 95 percent apple chop to which 5 percent

calcium arsenate is thoroughly mixed is being generally recommended. Complete control of the insects is being obtained with two applications, one applied just before the bloom period and the second applied the latter part of June. Tests are being continued for the purpose of determining to what extent this practice can be modified after a plantation has been cleaned up. Border baiting appears to have some promise in reducing the cost of control under such conditions.

Woolly aphis investigations. The established relationship of the woolly aphis to perennial canker infection makes the study of the insect of prime importance. Investigation of the life-history, habits, natural enemies, and more satisfactory control measures than now employed are being investigated. Sprays have been found ineffective unless the dead bark about cankers is first removed. Thorough cleaning up of rough bark and dead and diseased areas at the base of trees where apparently a large percentage of the overwintering insects remain retards reinfestation the following year. Nicotine-casein combinations have been found more effective as sprays than the summer oil applications.

Thrips control. Though sporadic in occurrence, two species of thrips, *Frankliniella occidentalis* and *Aeolathrips fasciatus,* often cause very extensive damage to apples in the Hood River district. Damage results from egg punctures made in the young apples about bloom time. Control sprays have been applied at bloom time and repeated within a week with best results. Nicotine has been found more effective than the oil applications. *F. occidentalis* appears to be a species feeding on a large number of native plants, leaving these for the apple orchards when the bloom is attractive. Extent of infestation in the orchards appears to be governed to a certain extent, at least, by conditions prevailing at bloom time. When the orchards bloom in advance of the native shrubbery, orchard infestations are greatly increased. Investigation of these insects will continue.

Hardiness problems—tree fruits. Extremely low winter temperatures during December, 1919, first indicated the need for growing only hardy tree fruits in the Mid-Columbia section. At that time the minimum reached 26° F. below zero. Trunk injury principally on the south or southwest side was most pronounced on apple and pear trees. Critically low temperatures in December, 1924, 1926, and January, 1927, also killed or severely injured an unusually high percentage of trees. Observations made on a field survey conducted during the summer of 1927, in which more than 16,000 apple and 2,000 pear trees were examined, indicate that leading commercial apple varieties, such as Newtown, Spitzenburg, Ortley, and Jonathan, also Bosc, Bartlett, and Anjou pears are subject to severe winter killing. The extent varied according to location. Orchards favorably located showed least injury. Apple varieties showing greatest resistance to winter kill are Arkansas, McIntosh, Astrachan, Arkansas Black, and Delicious. Flemish Beauty and Easter pear trees also proved hardy.

Studies bearing on the hardiness problem are principally centered around the propagation and testing of a large number of apple and pear varieties under average field conditions. The purpose is to determine

what hardy varieties can be used as stocks for top-working to semi-hardy varieties such as those above indicated.

For this purpose pears were propagated on the following roots: *Pyrus communis, serotina, calleryana,* and *ussuriensis.* Some of the leading pear varieties under test as stocks are Easter, Flemish Beauty, Comice, Vicar, Estella, Old Home, Variolosa Patten, and Tait No. 1. A large number of Oriental pear varieties, such as Hung Guar Li and Bali seedlings, are also under trial. Prominent among apple varieties under test for a similar purpose are Hibernal, Arkansas, McIntosh, Northwest Greening, Minnesota, Astrachan, Tolman 821, *Malus floribunda,* Canada Baldwin, Virginia Crab, and Haas. The ultimate value of many of these varieties will be determined only after the trees have been top-worked and brought into bearing. These and other varieties were chosen because they have proved hardy in other fruit sections where extremely low winter temperatures frequently prevail.

During the spring of 1926, approximately ten acres of full bearing Newtowns on the Station grounds which are planted thirty by thirty feet on the square were interplanted with Arkansas. The latter, in the summer of 1927, were top-worked (by budding) to several apple varieties. In 1928 very satisfactory development is shown. This system of orchard renewal possesses many advantages where proper spacing permits.

Control over trunk injury induced by low winter temperatures was studied from other angles. Shading of trunks on the south or southwest side during the dormant period proved partly effective. The purpose of shading is to reduce to a minimum variation in trunk temperature induced by warm, sunny days followed by cold nights. An experiment of this character with ten-year-old Anjou pear trees during the winter of 1925-26 indicates the value of such shading. Trees with trunks fully exposed show extensive bark injury compared with only slight injury to protected trees. Owing to mild weather, experiments of a similar character during the following winter did not give additional information on this problem. The value of whitewash as a means of protecting tree trunks is also being studied. Bridge grafting of injured tree trunks is another method employed to overcome the results of winter killing.

Variety testing.

Strawberries. A search is being made to find a strawberry variety possessing greater commercial possibilities locally than the Clark. The latter, although possessing first-class canning and shipping qualities, is a shy bearer, yields often not exceeding one hundred crates per acre. Ninety varieties, propagated by the United States Department of Agriculture, were planted in 1926 and 1927. Crosses between Howard 17 and Klondike, also 542 Mixed Cross, appear to possess merit as canners. They will be tested further under varying conditions. A large number of new varieties created by breeding work at the Home Station at Corvallis are also under trial.

Apples. The following varieties of apples are under test to determine quality of fruit: Spitzenburg (red strains obtained from the Southern Oregon Experiment Station and at Hood River), White Pippin, Starking,

Richared, and other strains of Delicious, Sweet Delicious, Lodi, and McIntosh. Hardy, Seckel, Patten, Minnesota 1, Cayuga Gorham, Conference, Phelps, and other pear varieties are also under observation. Golden Jubilee with other varieties of peaches and A-3 cherry are also under test.

Orchard fertility investigations. Experiments were continued relative to orchard fertilization. Results as a whole are consistent with that formerly reported. Use of fertilizers high in nitrogen in apple orchards employing cultivation and cover crops has resulted in slightly greater yields than where no fertilizer was used. In a 25-year-old Newtown orchard located on a well-drained Hood Silt soil, tests were made to determine the value of fertilizer applications in early spring. Plot 1 received an annual early spring application of three pounds nitrate of soda per tree in 1923 and 1924; Plot 2, two and one-half pounds sulfate of ammonia; Plot 3, eight pounds 6-10-4 (Clark's Special Brand) mixed fertilizer; and Plot 4, twenty-one pounds dried and ground sheep manure. During the years 1925 to 1927 inclusive, annual applications on Plots 1 to 3 were doubled. A four-year average annual yield per tree was 11.8 loose boxes as on the unfertilized plot. Plots receiving nitrate of soda, sulfate of ammonia, 6-10-4, and sheep manure yielded per tree in the following order: 14.3, 13.9, 13.7, and 13.5 boxes. Results thus far do not favor the use of other than simple, quick-acting nitrogenous fertilizers.

The use of commercial fertilizers, including sheep manure, in a full bearing Anjou orchard on a light Upper Valley loam has given no outstanding responses over that of unfertilized blocks other than in tree growth. Unfavorable pollination weather has hindered the set of fruit, making accurate conclusions unattainable.

Other fertilizer tests with apples and pears are in progress.

Strawberry fertilizer investigations. Experiments with a strawberry fertilizer carrying 6 percent nitrogen were conducted with the Clark variety. This element was combined with phosphoric acid and potash, the latter varying from none to 5 and 10 percent. Applications were made in summer immediately following the topping season and again during early spring. The amount applied semi-annually was five hundred pounds per acre. An average summary of yields for 1925 and 1926 shows 222 crates of 16 pounds net weight each per acre for the unfertilized plot compared with 307 crates for the plot receiving a 6-10-0 fertilizer. The addition of from 5 to 10 percent potash to the above combination has not increased yields on an average.

Potato fertilizer investigations. Tests in 1927 with Russet Burbank potatoes gave results of interest. Superphosphate and sulfate of ammonia were combined so that the proportions of the former by weight varied as follows: 20, 25, and 33 percent. This fertilizer was applied at the rates of 700 and 1,400 pounds per acre. The method of application was by means of a fertilizer attachment to the potato planter which placed the fertilizer at the same depth as the seed. The average yield from the unfertilized plots was 127 sacks (100 pounds each) per acre. Highest yields resulted from the 1,400-pound application in which 33 percent sulfate of ammonia was used. In this case the yield was 277 sacks. A

1,400-pound application of ammonium phosphate (20-20 combination) gave 254 sacks. The average yield from the 700-pound application was 206 sacks.

Picking and storage tests. Harvesting and cold storage tests were continued with Anjou pears. Pickings were made at one week intervals, beginning with August 14, 1926, and continued until September 18 in the Lower Valley, and from August 29 to September 18 in the Middle Valley. Best keeping quality was attained when pickings were made at dates approximately midway between the extreme dates above indicated and the fruit placed immediately in cold storage. The 1926 season was relatively early, being approximately ten days in advance of the previous year. Late pickings gave excellent quality, but long storage keeping capacity was shortened over that of earlier pickings.

Bosc pears were picked in the Lower Valley at dates ranging from August 14 to September 13. Pears picked about August 25 possessed good storage quality.

Picking tests were also made with Delicious, Ortley, Spitzenburg, and Newtown. Results, as a whole, favor early picking. A change in the greenish ground color on red varieties to slight greenish yellow was found the most practical test in determining picking maturity. The Newtowns during late seasons continue to grow until approximately the first of November, but best keeping quality is attained by picking between October 1 and 15. In 1926 pickings were made in the Upper Valley on September 20, October 13 and 30. Fruit was examined in cold storage on April 4, 1927. At that time apples in lots representing earlier pickings, although smaller in size, were clearly superior in quality compared with those picked October 30. The former were more juicy and of superior flavor, the latter somewhat "flat" and insipid. On the fruit picked on October 30, a red spotting was quite general due to overmaturity when harvested and to exposure to the late fall rains. Earlier-picked specimens were practically free from this spotting. Fruit in this test was held until an extreme date, June 3. Examinations showed the following condition of fruits:

Date picked	*Breakdown*	*Decay*	*Free of decay*
	%	%	%
September 20	2.7	-----	97.3
October 13	9.1	4.5	86.4
October 30	40.7	22.2	37.1

On June 3 fruit in the two earlier pickings was juicy and still possessed prime eating quality. The general color of skin was light greenish yellow. There was no evidence of shriveling. Fruit in the late-picked series was yellow and of poor eating quality. Fruit subject to break-down and fungous decay (Bull's eye spotting due to anthracnose and perennial canker infection) was also subject to blue mold decay.

Raspberry picking and canning tests. During 1926, experiments were conducted to determine the effect of time of picking Cuthbert rasp-

berries on canning quality. The influence of fertilizers and irrigation versus no irrigation was also subject to observation. Fruit was picked from patches growing on two distinct Hood River soil types, one a light sandy loam and the other a Hood Silt. Pickings were made during early ripening, at mid-season, and at the end of the harvesting season. Fruit was carefully picked and sorted into two distinct grades according to stage of ripeness as follows: light red, representing fruit slightly immature, and dark red to light purple, representing full maturity. Fruit was canned by the Libby, McNeil and Libby plant at The Dalles in sirup used in the "Choice" grade.

No outstanding differences in canning quality could be detected between berries from canes receiving irrigation and those not receiving irrigation. There was also no apparent difference in canning quality between lots representing various fertilizer treatments.

Best canning quality and appearance was obtained from lots representing nearly full maturity at time of picking. The fruits were larger and, as a whole, more attractive than those harvested earlier. The sirup was also somewhat darker red and slightly sweeter.

The tests as a whole indicate that Hood River Cuthbert raspberries, when carefully handled and picked at the proper stage of ripeness, possess first-class canning quality.

Anjou pear pollination studies. During the past five years, experiments were conducted to determine the influence of cross-pollination on Anjou pears. This variety very often fails to set a good crop, especially in years when unfavorable weather prevails during the bloom period. Bartlett and Easter pollen were used in experimental work in 1927 and 1928. Fall Butter was tested in 1928.

In 1927 the set of fruit (the blossom cluster calculated as a unit of one) was increased from 1.5 percent to 30 percent where Bartlett pollen was used, and to 44 percent where Easter was used. These results applied to Middle Valley conditions where unfavorable weather prevailed during blooming. As a result of favorable weather that year in the Lower Valley the normal set on open blossoms subject to cross-pollination by insects was 20.2 percent. Under these conditions the set was increased to 37 percent with Bartlett pollen and to 34 percent with Easter. Emasculated blossoms crossed with Anjou gave only 3.3 percent set.

In 1928 weather was unfavorable during blossoming in the Lower Valley and favorable in the Upper Valley. In the former case the set was increased from .64 percent to 18.7, 26.2, and 29.1 percent by the use of Easter, Bartlett, and Fall Butter pollen. The set on open blossoms subject to natural cross-pollination in the Upper Valley was 5.7 percent, but was increased to 23.9 and 34.7 by crossing with Bartlett and Fall Butter. Emasculated blossoms crossed with Anjou gave zero set. The effective control of pollination appears to involve the use of an ample number of pollenizer varieties and the use of bees as a means of transfer.

SHERMAN BRANCH STATION, MORO

The experiments in dry-farm crop production at this Branch Station have been continued with no essential changes. The scope of the varie-

tal testing work has been enlarged to include grain nurseries in all Columbia Basin counties for the purpose of determining more accurately the varieties best suited for the varying soil and climatic conditions existing in this territory. This grain nursery work, in most instances, is carried on in cooperation with the county agents. The main lines of investigational work at this Branch Station, which is maintained cooperatively by the State and the Office of Cereal Crops and Diseases of the United States Department of Agriculture, include:

(1) Varietal and rate-and-date of sowing experiments with wheat, barley, oats, peas, corn, and potatoes.

(2) Cereal-breeding investigations mainly with wheat for the purpose of producing high-yielding, disease-resistant, better-quality cereals.

(3) Tillage experiments to determine the most economical methods of handling summer fallow for winter wheat production.

(4) Soil moisture investigations to find out what effect various tillage methods have on the absorption and retention of moisture in fallow land.

(5) Crop-rotation experiments, mainly to determine what crops, if any, can be profitably grown in systematic rotations with grain on the dry lands of Eastern Oregon.

Varietal experiments. There will always be need in Eastern Oregon for carefully conducted varietal tests, especially with cereals. As new and improved varieties are developed, reliable information will be needed in regard to their merits and the locations in which they might prove superior to locally grown varieties. The Branch Station at Moro has already rendered valuable service in this connection to Eastern Oregon farmers by determining the actual differences in yields of scores of winter wheat, spring wheat, barley, and oat varieties; and by increasing and distributing to Oregon farmers seed of high-yielding, meritorious cereals. The Federation spring wheats, for example, first proved and distributed by this Branch Station, have revolutionized the spring wheat industry in Eastern Oregon by substituting two high-yielding, good-milling wheats for the numerous inferior varieties commonly grown. The production of Markton oats, a high-yielding, smut-immune variety, is another distinct achievement of this Station in this line of work. The detailed results of the varietal testing work at Moro are given in the following bulletins, copies of which are still available for distribution: Station Bulletin 190, Wheat Growing After Fallow in Eastern Oregon; Station Bulletin 204, Spring Crops for Eastern Oregon; and United States Department of Agriculture Circular 324, Markton, an Oat Variety Immune from Covered Smut.

Cereal breeding investigations. In the cereal breeding work at Moro during recent years emphasis has been placed on the production of a winter-hardy, early-maturing wheat variety similar to Federation, which has proved to be an unusually productive variety when grown from fall sowing without winter injury. Several promising hybrids have been grown in all nurseries in the Columbia Basin counties, and one new hybrid, Arcadia x Hard Federation, was grown in field trials by several farmers in 1928.

In connection with the production of smut-resistant wheat varieties suitable for commercial production, a very important discovery was made at Moro in 1927. It was learned that there was in existence in the Pacific Northwest a form of stinking smut entirely different and distinct from the smut with which experimental work has been done in Oregon and Washington. This form severely attacked several wheat varieties that in all previous trials had remained highly resistant or immune. Further studies in 1928 in cooperation with the Home Station have revealed the existence of several specialized strains or physiologic forms of stinking smut of wheat which vary widely in their ability to attack different wheat varieties. This discovery has greatly complicated the problem of breeding smut-resistant wheats; but the fact that there are a few wheat varieties that are highly resistant to all forms of stinking smut yet found gives hope that a good, high-yielding variety, resistant to all forms of smut, can eventually be produced.

A new spring wheat, a selection from Hard Federation, was distributed in the spring of 1928 to a few farmers for trial. This variety appears to be superior to Hard Federation in yield and in quality.

Tillage experiments. On the Branch Station at Moro, since its establishment, there have been in progress extensive tillage experiments, planned primarily to furnish information as to how various methods of soil cultivation influence wheat yields. The results of these investigations, which are given in detail in Station Bulletin 190, Wheat Growing After Fallow in Eastern Oregon, and Bulletin 1173 of the United States Department of Agriculture, have been directly responsible for higher acre yields of wheat in the Columbia counties of Oregon and in other dry-farming regions of the Northwest. Positive answers have been found for such troublesome questions as the value of spring and fall disking of stubble, the best time to plow, the right depth to plow, the use of packers, the effect on yield of harrowing winter wheat in the spring, etc. The information obtained in these experiments has done much to put the production phase of the wheat-growing industry in Eastern Oregon on a more certain and stable basis.

Crop rotation experiments. The great need for more crop diversification on our dry lands makes it extremely desirable to obtain all possible information on the actual yields of all crops that can possibly be grown, together with the effect on yields and on soil fertility of growing suitably productive crops in systematic crop rotations. Rotation experiments have been in progress on the Branch Station at Moro since its establishment. The results, in detail, have recently been published for the first time in Oregon Station Bulletin 209, Dry-Farm Crop Rotation Experiments at Moro, Oregon. The data presented in this bulletin, while emphasizing the superior crop yields obtained from the small grains on dry lands, show that at least one leguminous crop, field peas, and one cultivated crop, corn, can successfully be grown in rotations with grain on much of the wheat-growing area of Eastern Oregon. Of the many rotations tried with grains and other crops, from the standpoint of profit, the following were the most successful: (1) spring wheat—peas; (2) spring wheat—corn—barley; (3) winter wheat—fallow; (4) winter wheat—peas—winter wheat—fallow; (5) winter wheat—peas—peas; (6) spring barley—fallow.

Service rendered by Station employees. Branch Station employees are glad to respond, whenever possible, to calls from farmers for assistance and to the Extension Service and county agents for help in conducting farmers' meetings and field days. Each year one or more days are set aside for farmers of Eastern Oregon to visit the Branch Station. Field days are held annually at each of the cereal nurseries in Wasco, Jefferson, Gilliam, Morrow, and Umatilla counties.

SOUTHERN OREGON BRANCH STATION, TALENT

The work of this Station has progressed very satisfactorily during the past two years. Weather conditions have been favorable, plant growth has been vigorous and the crop yields large, enabling proper comparisons and satisfactory records. The additional results obtained during this period have brought some phases of a number of the projects to a conclusion.

Pear stocks. This is the largest project under way at this Station. Five distinct species of pears are used as stocks for our cultivated varieties of pears. These five include the old standard French stock and four other species which have shown greater resistance to blight than the French. In Southern Oregon, trees on all of these species have made vigorous and satisfactory growth when planted on deep, mellow, and well drained land. On shallow, and on heavy adobe soils, two of the species—the Japanese Sand Pear and the Ussuriensis—are proving unsatisfactory. Under these conditions the trees usually become stunted and under severe conditions often die after the first few years' growth. Since much of our soil is very heavy adobe and considerable of it shallow, these two species cannot be generally recommended for this Valley.

Far more satisfactory results are being obtained with *P. calleryana* and *P. betulaefolia.* The trees on these two stocks, now seven years old, are much larger and much thriftier than those on *P. ussuriensis* and *P. serotina* on our heavy upland soil. In fact, at this age they are larger than the trees on the standard French stock. Whether this superior vigor will continue as the trees become older only time will determine. Unfortunately, it will require at least ten more years to determine the ultimate behavior of our varieties on these new stocks. Since these two species are more resistant to root blight and pear woolly aphis, and since *P. betulaefolia* is also far more resistant to alkali than the French stock, the importance of the experimental work in progress is apparent.

There is a great variation among the seedlings of each of these species of pears. Some of the strains and individuals are far superior to others in vigor, type of root system, and resistance to blight. Most of the time on this project is now devoted to the determination, isolation, and propagation of these superior strains. Superior strains have already been isolated and are now being propagated.

The French rootstock is admirably adapted to the peculiar soil conditions of Southern Oregon, and is a highly congenial stock for our cultivated varieties. Selection work with this stock, therefore, is more extensive than with all the other species combined. The varieties and

seedlings show great variation in vigor, habit of growth, and resistance to disease. This offers unusual opportunity for selection.

For many years the Station has been searching for a vigorous, hardy, blight-resistant trunk and framework stock for our varieties of pears. Among those thoroughly tested the two most promising are Old Home and Variolosa. While Old Home is extremely vigorous and highly resistant to blight, the young trees, under certain conditions, have proved susceptible to a peculiar canker disease on the trunk. Work is now in progress to determine whether this can be prevented. The Variolosa has proved a promising trunk stock. It is highly resistant to blight, an excellent grower, with desirable framework, and makes a good union with our commercial varieties. This work is being extended.

Blight resistance in pears. This project, discussed in the preceding Biennial Report of this Station, is being continued along the same lines, although certain phases of the work have been materially enlarged.

In the extensive inoculation work conducted during the past fourteen years, the degree of susceptibility to pear blight has been determined for each of the various species of Pyrus. Of thirty-four species tested only five showed sufficient resistance to blight to justify a continuation of the work after the first ten years. In each of these five species some individuals have been found which so far have proved immune to blight, but in each species many seedlings are not resistant. Extensive work is now in progress to determine resistant varieties or individuals which will transmit blight resistance to their seedlings or offspring.

Three species show highly resistant individuals which have the power to transmit to their offspring this characteristic of blight resistance to a remarkable degree. In *P. ussuriensis,* a variety known as Ba Li Hsiang has given the most resistant seedlings. In *P. calleryana,* Talent Station selection Calleryana No. 2 has given a remarkably high percentage of resistant seedlings as compared with the seedlings grown from the variable imported Chinese seed.

The chief pear rootstock in this country is the French, *P. communis,* imported every year by the millions. Most of these are highly susceptible to blight. Among the hundreds of varieties and the thousands of seedlings tested, however, a small number have been found which show high resistance to blight. Work with one of these, Old Home, has shown that it gives a far higher percentage of seedlings resistant to root blight than is found among the variable seedlings now imported from France. Experiments are now under way to determine what male parent, in combination with Old Home, will give the most resistant seedlings. This year (1928) seedlings of a large number of other French varieties are under test to determine whether any of them will give higher percentage of resistant seedlings than the Old Home.

Spraying for pear blight. During the past five years this Station has conducted experiments with bordeaux mixture as a preventive for pear blight. During four of the five years there has been a marked reduction in the number of blight infections in the plots sprayed with 6 pounds of bluestone and 12 pounds of lime in 100 gallons of water, applied just before blooming and again immediately after blooming. Experiments

are now in progress to determine whether this spray can be applied earlier in the season with equally effective results, and thus prevent the slight russeting experienced some seasons on certain varieties with the present program.

Pear picking tests. Experiments conducted during the past three years in cooperation with the Central Station at Corvallis, have shown that some of our varieties of pears have a very short picking season and that heretofore they have often been picked either too early or too late—usually too late. The experiments show that the quality can be improved, core breakdown prevented, and the storage season lengthened by picking at the proper season. With the pressure tester developed by the Oregon Agricultural Experiment Station, growers now have a reliable guide for the determination of the degree of maturity of the fruit on the tree. With numerous pickings made each year for three years, and a pressure test made of each picking, and a careful study of the development of each lot, both in common and cold storage, remarkably valuable results have been obtained. This work has already had a tremendous influence on the commercial industry here.

Cold storage of pears. During the past three years extensive cold storage experiments with pears have been conducted in cooperation with the Central Station at Corvallis. We have found that the time of picking, promptness in storing, and temperature at which stored, all have a profound influence on the length of time the fruit can be held in storage, on the quality developed and the amount of core breakdown. It has been definitely ascertained that previous to this work some of the varieties were often held too long in cold storage for satisfactory results.

Pear breeding. The numerous pear hybrids produced a number of years ago by crossing our best American varieties with some of the most blight resistant Chinese varieties, have made a satisfactory growth, and a portion of these are fruiting for the first time in 1928. When ripe, the fruit of these will be studied to ascertain whether any with good quality and high resistance to blight have been obtained.

Pear variety collection. The large variety collection of pears planted in 1913 has been maintained. Much valuable information is being obtained on such items as vigor, productiveness, quality, and especially resistance to pear blight. The trees are all in bearing now and some promising new varieties have been found. Among these are some of exceptionally fine quality.

Codling-moth investigations. Investigations for methods of better codling-moth control are being continued. The effectiveness of the oil and arsenate of lead combinations has been demonstrated and the ineffectiveness of oil alone has been shown. Oil in combination with arsenate of lead has resulted in as high as 15 percent cleaner fruit than when arsenate of lead was used alone. All of the oils used on Newtown apples by this Station have caused considerable injury to the fruit and many of them to the foliage. The work during the present season is being carried on mainly from the standpoint of injury. Several new weights of oils and oil types are being tested.

Red spider investigations. The red spider, during the past three years, has become a major pest in our orchards. Due to susceptibility to lime-sulfur sprays, summer oils have been investigated for control of this insect. Early applications have proved most satisfactory and heavier types of highly refined oils more permanently effective than lighter types. No apparent injury to pear fruit or foliage has been observed from use of these high grade oils. Studies of the keeping quality of pears have shown them to be relatively unaffected by one or two applications of oil spray.

San Jose scale investigations. Experiments have been continued during the past two years for control of San Jose scale. The accumulative effect of repeated applications of oil is being noted and compared with lime-sulfur. Injury to foliage and blossoms and delay in leafing out after oil applications have made necessary a study of oils suitable for sprays in the delayed dormant. Wet orchard conditions in the spring often force the application of dormant sprays at this time. Experiments in an effort to avoid spring spraying by fall spraying are being conducted. Injury from fall applications of oil sprays has amounted to as much as 100 percent kill of fruit and leaf buds of the pear variety Winter Nelis, and lesser amounts of injury on other commercial varieties of pears. No injury has been observed following fall applications of oil on Newtown. This work will have to be continued for observation through a severe winter.

Injury of dormant oils to Winter Nelis pears. Winter Nelis pear trees have been severely injured by dormant sprays of oil. There is considerable acreage of this variety, often interplanted with other pear varieties, not injured by present oil sprays. The grower is either forced to use a more expensive lime-sulfur spray or to spray the Winter Nelis separately. Injury to Winter Nelis is being investigated. All of the leading commercial types of dormant oils and home-made emulsions have caused more injury than could be permitted, killing from 10 to 50 percent of the fruit and leaf buds. This injury has developed irrespective of cold temperatures. This investigation will have to be continued.

Dry lime-sulfur vs. liquid lime-sulfur. Dry lime-sulfur as against liquid lime-sulfur has received considerable discussion in this Valley. In experiments during the past two years, the strength of 30 pounds dry lime-sulfur per 100 gallons of spray material, as is recommended by spray companies for heavy infestations of scale, has been found less than half as effective as full strength liquid lime-sulfur 1-8. Liquid lime-sulfur 1-16 has given better control than dry lime-sulfur 30 pounds per 100 gallons of spray at less than half the cost for spray materials.

Minor work. In the extensive work on orchard cover crops conducted here since the Station work was started, numerous legumes have been tested. The Hungarian vetch has proved the best one of these for the very heavy clay soils of this Valley. In tests conducted at this Station during the last two years Harding grass has made an excellent showing. This promises to be a valuable crop for the Rogue River Valley.

During the past three years interest has developed in the type of Bulbous blue-grass—possibly *Poa bulbosa,* brought here about ten years ago from Chile. On fertile soils this is a valuable winter pasture grass here from about the first of October until May. This Station is conducting tests with it on some of the non-irrigated soils which are now practically idle.

EASTERN OREGON EXPERIMENT STATION, UNION

LIVESTOCK

Growing heifers. In the fall of 1924, 100 head of weanling heifers were put on test to determine the best methods of wintering growing heifers. They were divided into five groups of twenty each and have been wintered in five different ways for the past four winters. Half of each group was bred to produce the first calves at the age of 24 months, the other half to produce their first calves at the age of 36 months. Those which were bred to produce calves at 24 months gave us that year (1926) an 80 percent calf crop; and in 1927, a 77 percent calf crop, while the heifers which had not calved the year before produced an 83 percent calf crop. The heifers which had not calved the year before weighed in October 73 pounds more and their calves 7 pounds per head more than those of the other group.

To further test the residual effects of early breeding, this experiment is being continued into 1928. It will probably be completed at the end of that year.

Heifers wintered on a limited ration of alfalfa or a ration of straw and alfalfa are apparently as good breeding cows as those which were fed more heavily, although they are not quite as large. The use of grain during the winter has been financially unprofitable and there is little evidence that the heifers are better producers, although they are in somewhat higher condition, especially at the end of the winter.

Baby beef. Two tests have been conducted with short-fed baby beef in which it has been shown that weanling calves fed an average of 15 pounds alfalfa hay and 5 to 6 pounds of grain will gain 1.9 pounds per day. At the end of 5 months feeding they produce beef of attractive appearance and good quality. This beef is tender, but has a slight veal flavor and is not as satisfactory as two-year-old beef fed in a similar manner. Packers are divided in their opinion as to the value of this beef. Some packers are undecided on the whole question. The present need is for technical studies on the quality and palatability of the type of beef rather than for further feeding experiments, although some of the latter will be necessary. In the latter connection we have already shown that all of the common grains, corn, wheat, barley, and oats, are suitable and usable for this purpose. We have also shown that the use of oil meal in addition to alfalfa meal is unnecessary.

Growing steers. Five experiments testing out various methods of wintering growing steers and involving 33 lots and 10 years in time were completed in the early part of the biennium. The financial phases of this experiment have been summarized in bulletin form, but not yet published. The feeding phases of the experiments have been published in Station

Bulletin 224, Wintering Stock Steers. A popular summary of this bulletin follows:

(1) The gains made in the winter time on any kind of hay, straw, silage, or grain are very expensive, so much so that every pound of gain put on costs more than the market price of beef, even when beef is high.

(2) Calves or yearlings may gain in weight and lose in fat at the same time.

(3) If stock steers are so fed as to make large gains in the winter, they will make smaller gains the following summer on grass. For every extra pound that a steer gains in winter, he will make at least one-half pound less gain the following summer on grass.

(4) The kind of feed used for wintering purposes does not seem to influence the gains made the following summer on grass, provided the amount of gains made during the winter remains the same.

(5) The value of any given feed for wintering purposes may be altogether different from its value for fattening purposes.

(6) Within reasonable limits, the amount of feed necessary to winter a calf or yearling without gain or loss depends on his size.

(7) The gains made by wintering cattle are not in proportion to the total feed consumed but are in proportion to the amount of feed in addition to that required merely to maintain the animal's weight.

Lambs. A farm flock has been continued as a demonstration unit and as an economic study. Our work shows that a lamb crop of 100 percent will pay reasonable market returns for all feed and labor and interest on the investment. Lambs in excess of this figure are profit. Our lambing percentage is still averaging in excess of 150 percent.

Winter fattening experiments with lambs have been conducted to determine the value of various cereals, of molasses, and of chopped alfalfa and alfalfa meal. This material is now being prepared for publication.

Pigs. Pig feeding work during the biennium has centered around the question of the proper supplements for barley and alfalfa pasture. Results show that a mineral mixture is practicable under these circumstances. The use of tankage or skim milk in addition to barley and alfalfa pasture has produced a very slight additional gain but so small as to be within the limits of experimental error. The maximum gains have been produced, however, on check lots without pasture provided the pigs received both tankage and skim milk in addition to minerals and barley. Similar lots at Corvallis without the milk have not made maximum gains.

Dairy herd unit. The dairy herd unit was continued and somewhat expanded. There are now approximately fifty females of various ages in the herd. Not a great deal of real experimental work has been attempted. The herd, however, has served as a demonstration of methods and equipment, and as an outpost for adaptation tests of herd management,

feeding selection based on milk records, and breeding to build up an economic herd.

In addition to the outstanding herd sire which was purchased as a calf some years ago, two "proved sires" have been added to the herd. The offspring as a whole are giving better results than the older cows, both in conformation and butter-fat production.

Modern milking-machine equipment has been in operation for the two years with satisfactory results. The man in charge of the herd prefers to milk approximately 25 cows with the milking machine rather than 15 to 17 by hand milking. The object of this test was to obtain data relative to the economy as well as general usefulness of the milking machine. Records have been kept on comparative time of milking, cost, and general results.

In connection with the management of the herd, pasture experiments have been started; but fencing, establishment of proper stand for experimental work, and other factors have not been in shape such that experimental data are yet available.

"Sleeping sheds" have been built to house the cows in production, except while they are being milked and have had concentrated feed. This is aimed to test the "sleeping shed" arrangement for herds under Eastern Oregon climatic conditions.

Five pure-bred males have been turned over for use by dairymen of the county under a definite agreement similar to the plan of the Federal Department in connection with investigations in the "proved sire" project. These animals remain the property of the Station and will probably be assigned to new farms in the course of a few years. The whole plan is in cooperation with the Agricultural Committee of Union county.

Poultry unit. At the request of people in the vicinity a poultry unit was started at this Station in the spring of 1927. Some five hundred pedigreed Barred Rock chicks were hatched, at the Corvallis Station, and shipped to the Union Station. A like number were hatched and shipped in 1928. The 1927 stock are now in production. The Station's recommendations as to brooder houses, laying house, other equipment, and general management are put into application. Farmers are appreciating this unit as a demonstration of practical methods and equipment. The idea is to have approximately a 400-hen unit, managed according to recommendations of the Station and College for this size unit in the state. Full record will be kept of all cost for land, housing, feeds, losses, labor, and a complete record of all returns from the flock.

FIELD CROPS

Varietal trials. The extensive plantings for comparative tests of spring and fall wheats, oats, and barleys, were continued. Varietal trials were continued also of peas, flax, vetches, and combination crops. There are some promising new select strains and varieties, but tests have not been under way long enough to justify recommendations.

Nursery trials. Spring and winter cereal nurseries were continued at Union, and cereal nurseries were established in Wallowa county under supervision of this Station. These cereal nurseries follow the same plan and use many of the same varieties used by the main cereal Station at Moro in its central station investigations, and in nurseries throughout the Columbia Basin. The idea is to have all such work closely coordinated as to plans and results.

Rotations. The comprehensive crop-rotation system was continued. Some difficulty has been encountered in the continuous cropping on account of quack-grass. These tests, of course, are carried on for their value in the future rather than for any short-time results.

Fertilizers. The fertilizer rotation was continued. There is some variation in results from commercial fertilizers, but to date no commercial fertilizer has given such results as to warrant commercial adoption.

Tree nursery. The tree nursery was continued to propagate ornamental trees for planting along state highways.

Irrigation. The irrigation under pumping on sandy soils was continued during 1926 and 1927. The object was to determine the advantage and feasibility of irrigation for field crops under these conditions. The small plant was established in cooperation with the Oregon Committee on Relation of Electricity to Agriculture, the Eastern Oregon Light and Power Company, and the La Grande Chamber of Commerce. The results of irrigation were outstanding on alfalfa. It is doubtful whether the test is sufficient, however, to warrant reliable conclusions as to the economic feasibility of irrigation development in that section.

GENERAL SERVICE

Members of the Grange hold their annual meetings and picnics on the Station grounds. Several counties combined such meetings.

The Station staff has had much to do with the successful livestock show at Union. The Station facilities, especially livestock, have been available and used by Smith-Hughes teachers and students.

The Station has been used more by visitors than in the past, through conferences and examination of field crops, livestock, dairy units, hog unit, and poultry unit. Attempt has been made to have facts and equipment where they can be studied in connection with the livestock management.